SAE JOURNAL

ANNUAL PRODUCTION ISSUE

featuring

PRODUCTION DESIGN PARTNERSHIP

MAY 1954

PUBLISHED BY THE SOCIETY OF AUTOMOTIVE ENGINEERS

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dangerous . . . and costly!

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34 out of 36 engine manufacturers specifying chrome rings use

Perfect Circle

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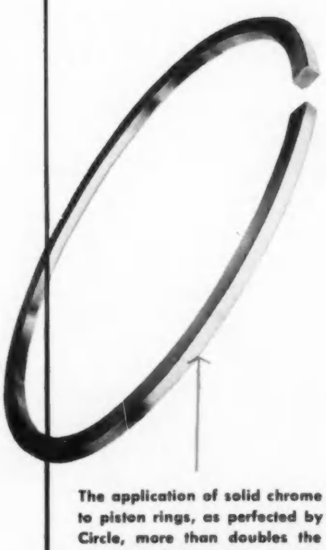

The application of solid chrome plating to piston rings, as perfected by Perfect Circle, more than doubles the life of pistons, cylinders and rings. Complete performance data will be sent upon request. Perfect Circle Corporation, Hagerstown, Indiana; The Perfect Circle Co., Ltd., Toronto, Ontario.

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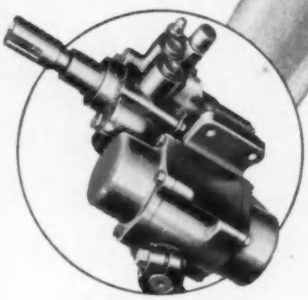

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For the Sake of Argument

Stencils of the Mind . . .

By Norman G. Shidle

The entrance to each mind is like a stencil. Rarely is it a wide opening, unobstructed by preconceived notions of some kind. Each person's environment, habits of thought, and frame of spiritual reference combine to cut the pattern for his individual stencil.

For each of us, a stencil stands there at mind's entrance, like a porter at the door of thought. . . . And, depending on its pattern, it lets in some aspect of each idea that tries to enter; excludes some other phase.

When an idea has been squeezed through our stencil it tends to look something like every other idea that has gotten through. It may little resemble what came from the original sender's mind.

The finer the lines of our stencil, the less of the sent-idea gets through. A fanatic is really just a man whose stencil has come to be but a single pinhole.

Some stencils seem to strain out the bad, the pessimistic, and the unfavorable from what comes to the mind's attention. Such stencils let in all the good, the optimistic, the loving.

Others, it would seem, are cut to let through only the needs-to-be-criticized aspects of whatever presents itself.

The facts let through to the first sort of man convince him that God's in His heaven and all's well with the world. He feels himself surrounded by friendly, attractive, good people. . . . Those let through to the second man make him equally convinced that practically nothing is right with the world—and there probably isn't any God! He feels the world is full of evil, stupid, and unpleasant people.

Each of us cuts his own stencil . . . and there are those who will claim a well-cut stencil is more to be desired than an open mind.

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PRODUCTION DESIGN PARTNERSHIP

Edward H. Kelley, General Manufacturing Manager, Chevrolet Motor Division, GMC

"The growing complexities of present and future engineering problems will progressively require closer and closer collaboration between the Engineering and Production team to ensure the progress, stability, and even the survival of the manufacturer they serve."

PRODUCTION

E. N. Cole, Chief Engineer, Chevrolet Motor Division, GMC

"Engineering and Production, as a team, can do together what neither can do alone: Provide a stimulus to sales by offering the buyer what he wants at a price he is willing to pay."

DESIGN TEAMWORK

To see how Chevrolet's Production and Engineering team functions, turn page ⟶

Production-Design as Viewed by Production . . .

by Edward H. Kelley

NOWHERE in industry is teamwork more evident or necessary than that practiced by the engineering and production groups in a typical automotive organization. Each group has its own specific field of operation; but neither can function as a separate unit for long before being faced with need for contact with the other.

I shall try to outline briefly the following items:

1. Specific duties of the various departments in the production organization.

2. How the duties of these departments tie in with the engineers almost from inception of the product.

3. How their requirements modify design of the product.

4. How solution of mutual problems has a potent effect on the overall design from a cost standpoint.

Receipt of the engineering release and supporting prints set off a chain reaction in the various departments of the production organization. See Fig. 1. Each department in the production organization has both specific responsibilities and the general responsibility of facilitating all other departments in accomplishing their mutual goals of (1) quality production, (2) on schedule, (3) in the required volume range, and (4) at the lowest cost consistent with these objectives.

Certain production departments assist and collaborate with the engineers. Invariably this is done through the Production Engineer, even in the designing and testing stages—long before the tested design is released for production. See Fig. 2. These production departments include, but are not limited to, Standards, Master Mechanic, Metallurgical, and Purchasing.

Here is how the various production departments function with engineering to achieve the triple objective of quality, volume, and cost:

1. Standards Department

One of the chief functions of the Standards department is to develop data on tools, equipment, and labor costs. These data are used by engineering to decide whether a contemplated change is worth the cost.

The Standards and Master Mechanic's departments must work very closely in developing costs,

Continued on Page 22

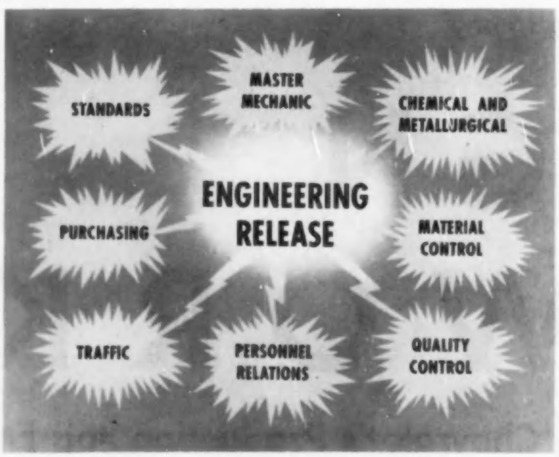


Fig. 1—A release from engineering puts into action these departments of the production organization

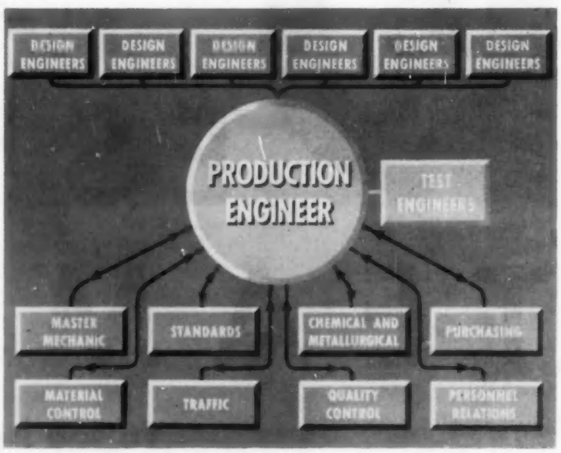


Fig. 2—The Production Engineer is the link between engineering and the manufacturing groups

Teamwork At Chevrolet

. . . as viewed by Engineering

by E. N. Cole

COST and quality are the reason for the engineering-production team. Time is the reason for the closeness of their cooperation.

The closer we can come to designing a product that meets the demand of Bill Knudsen (Chevrolet's master of production in the 20's and 30's) for a product that can be "built good-easy," the better, the more economical, and the more dependable our product will be.

Let me cite one example of cooperation leading to product improvement. It will give you an idea of the mechanism of cooperation.

1. New Part, New Process

When the Powerglide transmission was in the design stages, nearly everyone in the industry was using an aluminum valve body in automatic transmission. This material is a natural choice since it can be easily cast and has a smooth surface.

These are the reasons aluminum is used in the Powerglide automatic shift valve body. However, cast iron seems the more advantageous material for the main valve body and we wanted to use it.

But before we could go ahead with this material in our part (see Fig. 1), we had to prove to ourselves and to management that it would be possible and practical.

Fig. 1 shows the development of the cast-iron valve body. It gives you an idea of how the contributions of engineering and production are integrated by the Production Engineer. As you see by the chart, the Production Engineer is the key man. He serves both engineering and production by making the designer aware of production problems and by bringing all design engineering resources to bear on production problems.

First step in the flow chart is release of the design to the Production Engineer. He immediately contacted the foundry representative, explained engineering's requirements, and asked for suggestions. The foundryman requested more draft on the thin walls between the oil passages.

Since such a change could modify passage flow characteristics, the request was relayed to the design engineer for his study and approval. He provided the additional draft requested and returned the modified drawings to the Production Engineer. The foundry then cast the the first samples in green sand. But the surfaces resulting from use of green sand were too rough for satisfactory oil flow through the passages.

The foundry next made a dry sand core and treated it with graphite to prepare a smooth surface. The first pouring attempt failed because the sand crumbled under the weight of the metal. The weakest parts of the core, the thin wall sections between the passages, were then reinforced with wire stiffeners. The next pouring was a success and produced a casting with the required surface.

These samples were sent out to be machined. They were badly distorted when returned, indicating the need for stress relieving.

Still another new problem cropped up at this stage. One of the machining operations was boring holes for the valves. These holes passed through a number of oil passages and had to be held, in the final bore, to within 0.0002 in. When the precision

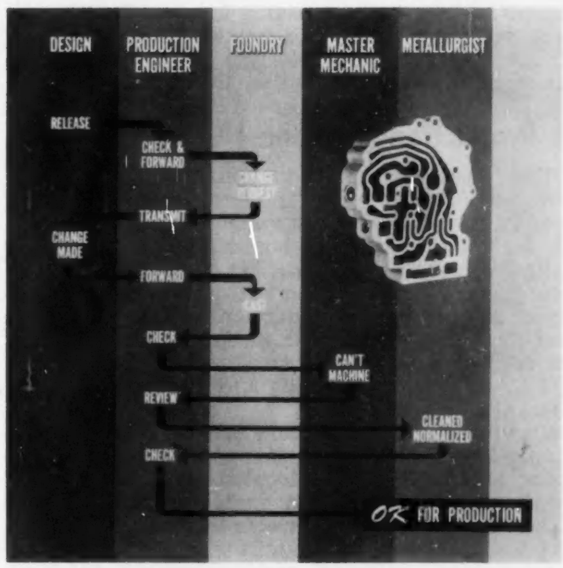


Fig. 1—It took integration of production and engineering efforts to develop a producible cast-iron valve body for Chevrolet's Powerglide transmission

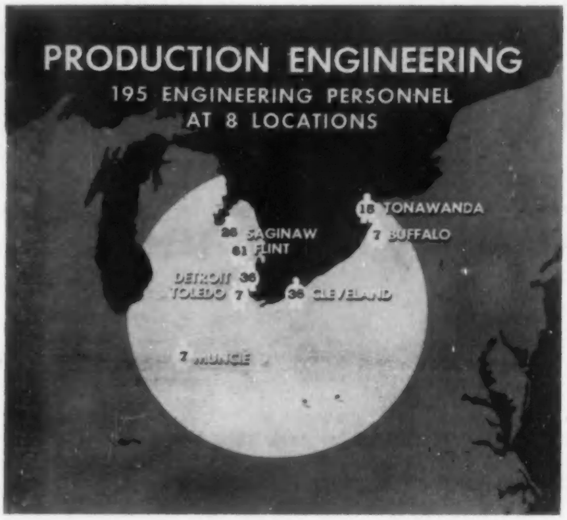


Fig. 2—Here is how members of Chevrolet's Production Engineering group are dispersed throughout its manufacturing plants. In addition, there are 11 others contacting assembly plants

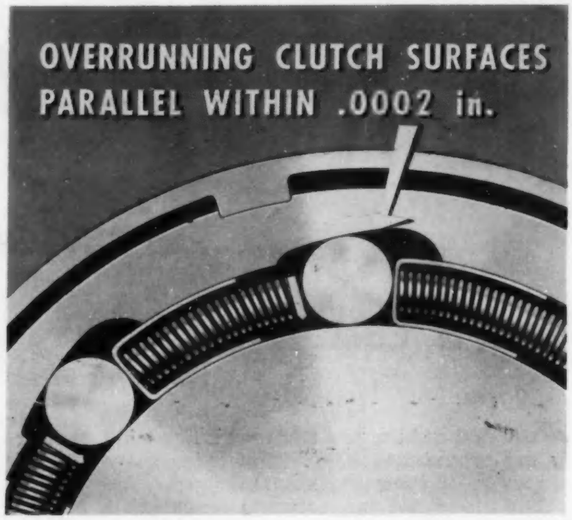


Fig. 3—The extremely tight tolerance required, as shown here, for proper operation of Powerglide gave birth to an ingenious machine

boring tool passed through the body, it encountered sand imbedded in the surface of the iron. This sand quickly ruined the tool.

These problems were turned over to the metallurgist. The stresses he relieved by normalizing. Then, with cooperation of vendors, the metallurgist came up with a caustic salt which dissolved all the silica in the surface of the casting. When the chemically cleaned castings were machined, there was no further trouble.

At this point, engineering and production were confident they had succeeded in proving that the cast-iron valve body was a practical design. When its advantages and practicality were pointed out, management approved the part.

2. Production Engineer—Human Catalyst

You have seen the Production Engineer at work. Now let's focus on him. The first Production Engineer was originally a design engineer who wandered too far from his drafting board while following his designs through the plant. He became so familiar with production techniques that he was more valuable as a liaison with production than he was as a designer. Instead, he was given the responsibility for adapting designs for production requirements and integrating engineering and production activities.

Chevrolet engineering now has several hundred people in the Production Engineering department. Some are permanently located at plants where they're known as resident engineers. Others, the liaison engineers, make periodic trips to all assembly and sheet metal plants to assist with their problems.

As Fig. 2 shows, there are 195 people representing Production Engineering at eight locations. And 11 engineers keep contact with 11 assembly plants.

The Production Engineer starts his duties before the design has been released. In the first design stages, he consults the production people on matters affecting design utility. Take tooling, for example, The Design Engineer has only a sketchy idea of how his design will affect the tooling picture. Before he spends too much time on the design, he must know how much new tooling it will require, how much it will cost, and how soon it can be obtained.

Chevrolet must amortize machine tools according to a predetermined schedule so their cost will not be an unwieldy impediment to progress. So we must have close cooperation between the design and tool engineers. Often production can save unnecessary tool costs by minor changes in initial design.

Another way to look at this is to consider scheduling of available machine time. At first glance, forging may seem to be the most economical way of producing a design. But if the forging shops are loaded with jobs, new facilities would have to be purchased.

Rather than do that, production might suggest that the design be changed to a stamping when it has idle stamping capacity. Such design changes can mean the difference between meeting or exceeding the projected final cost.

After the design is released, it is reviewed by the Production Engineer who asks: "How practical is it to manufacture?" Some practical considerations he looks for are so simple and remote from the design's function that the designer may overlook or dismiss them. For example, if large stamped parts such as hood panels are not designed so that they will nest, their shipping charges may be doubled or tripled.

He also looks for dimensional tolerances which are too close to be held on production machines, tolerances too broad for satisfactory field service,

or specified assembly and gaging methods which are too broad to insure a better product and effect economies.

Production Engineering has extensive test facilities to verify changes it may insist on. Although testing isn't so broad in scope, Production Engineering can test more engines in a week than Chevrolet's Experimental Laboratory can test in a year.

The Production Engineer also gives vendor approval. This job is complicated by Chevrolet's extraordinary volume. Often, the approved vendor doesn't have enough capacity to fulfill all our requirements. Last year, four vendors supplied roughly 31 million piston rings used in Chevrolet vehicles.

3. Powerglide Teamwork

No assembly developed in the automotive industry in the last 20 years was more critical than the Powerglide. It was an entirely new assembly and we had no precedent to guide us.

We gathered a team of production engineers and representatives of all production departments. As soon as information was available, first as a layout and then as a detail sketch, the Production Engineers conferred with the production groups to learn their requirements. Everyone asked: Can we make it at a lower cost? Can we make it better? Can we make it easier? As suggestions were made by the production group, they were relayed to the design group in Detroit on a day-to-day basis.

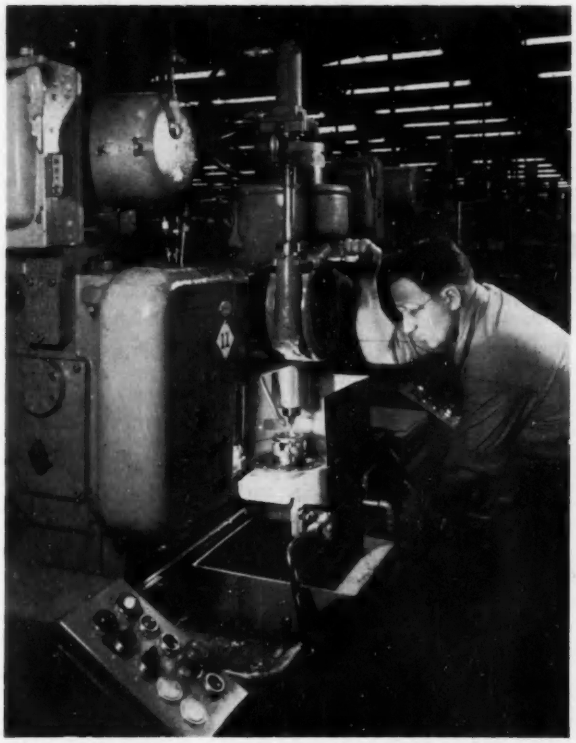
What was really going on was a conference between the production group in Saginaw and the design group in Detroit, with Production Engineering as the instrument of communication. In this way, production requirements were incorporated into the experimental design. That avoided, as much as possible, the need for redesign after the experimental tests.

The production metallurgist wrote his own ticket on specifying materials and heat treating. The design engineer usually specifies the steel to be used. Nine times out of ten he will select one of the commoner steels, like SAE 1010 or 1020. But the metallurgist chose SAE 1117 for the same application, because it could be machined faster and was easier to heat treat. Instead of the usual SAE 1140, he picked SAE 1137 because it would lengthen cutter life.

His choices were wise. It was not necessary to go back and approve alternate materials for manufacturing convenience after production was started.

4. New Tool Conceived

One of the outstanding characteristics of this group was the open-mindedness with which it approached any problem. Engineering asked produc-



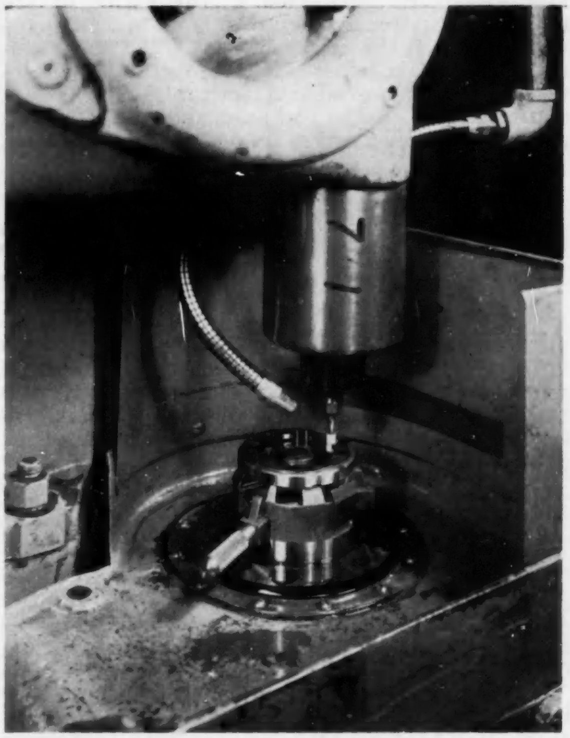


Fig. 4—A Fellows grinder equipped with an air turbine (at left) did what no commercially available machine tool could do: produce the cam surfaces within specified tolerance (as shown in Fig. 3). The photo at right is a closeup of the cam in the fixture

tion to finish the cam surfaces for the overrunning clutch in the Powerglide to within 0.0002 in. of parallel. (See Fig. 3.)

Unreasonable? Yes, because no machine tool manufacturer would build a machine which could finish the surface closer than 0.0015 in. of parallel. Unreasonable? No, because if we did not finish to that specification, the rollers in the clutch would not lock and unlock properly. Resulting friction would have made Powerglide just another automatic transmission.

The answer was provided by the master mechanic. He appreciated the necessity of our request and set about creating a machine which would give us what we needed.

The rest of the industry was using a broach to finish the cam surface. A broach could operate within the limited access presented by the cam surface. But how to grind, when there was room for only a 5/16-in. grinding wheel. To drive the wheel at the required surface speed, tremendous velocities would be needed. The master mechanic found a way.

He found an idle Fellows grinder. For the regular drive, which was much too slow, he substituted an air turbine which would drive the wheel at 65,000 rpm. That broke the bottleneck; but he wasn't satisfied. He persisted in refining his design until he produced a machine which would stroke, index, and describe the curve of the cam surface—all automatically. His last touch was to provide the machine with an automatic device to dress the wheel. The machine is shown in Fig. 4.

It was so successful, we are now using 25 of them.

But the story doesn't end there. We had to know how Powerglide performed in the hands of the owner. No matter how thoroughly we test any part, owner usage is the conclusive test. The field product engineer, a member of the Production Engineering department, examined warranty reports and material sent to the material return room. He alerted us when a trend seemed to be developing. At any indication of trouble, we moved quickly to determine whether the problem stemmed from faulty design or manufacturing quality, and devised corrective measures.

5. New Horizons

An area which we give a great deal of attention is the assembly plant. Here a considerable number of manhours are consumed in putting together fabricated parts. The point is not whether two parts will go together without interference, but how quickly can they be properly put together. And more attention is being given to parts standardization and elimination of unnecessary parts.

To exploit these opportunities, the Production Engineering department has added a number of engineers known as the assembly plant liaison group. They maintain contact with all assembly plants and encourage design modifications to take full advantage of new methods and equipment.

Fitting sheet metal is nearly always a source of problems in assembly plants. Not only must the assembly be checked for the absence of interferences between parts, but sufficient clearance must be allowed for use of assembly tools. The most efficient assembly sequence must be planned. The assembly plant liaison group eliminates many of these problems by making a production design check of the front end sheet metal.

So far, we have merely scratched the surface. Every day shows us in some new way that responsibility for constant improvement bears equally on the shoulders of production and engineering.

(Paper on which this abridgment and the one by E. H. Kelley is based, "The Engineering and Production Team," was presented at the SAE National Production Meeting, Chicago, March 30, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

as Viewed by Production . . .

—continued from page 18

methods, and processes—both before as well as after the design is released. Standards also is responsible for plant layout, established with the Master Mechanic and Plant Engineer. Time studies, line speeds, and cost control are other functions of Standards.

2. Master Mechanic's Department

The Master Mechanic's department has perhaps even closer, more frequent, and important contacts with the Production Engineer than any other production group.

In determining the best methods of fabrication, the resourceful Master Mechanic and cooperative Production Engineer often arrange to build the new design without excessive and unwarranted expenditures for facilities. In the area of adapting existing facilities to new design needs, the Master Mechanic will request or recommend design changes to hold down expenditures for new equipment or manufacturing space.

The Production Engineer will refer these recommendations to appropriate members of engineering. Often these efforts prove fruitful.

The Master Mechanic provides machines as well as the tools, dies, jigs, fixtures, and gages, including the design of these items.

3. Chemical and Metallurgical Department

This department establishes heat treat, plating, waste control, and disposal processes and procedure, and approves related equipment. It also tests both raw and processed materials for chemical and

metallurgical content. Close liaison is maintained with engineering in developing processes and equipment for new design or specifications to accommodate proposed changes into existing equipment, where possible, without penalizing progress or quality.

Contact with engineering is required when laboratory tests of materials received indicate the material is not strictly in accordance with specifications, but will still produce the desired results. For example, in some instances tests may disclose material to be low with respect to one alloy and high on another; but specified hardness can still be obtained. Collaborative efforts with engineering also are maintained to avoid or minimize high-volume waste generation and expensive disposal processes and facilities.

4. Purchasing Department

Immediately after engineering releases and appropriate prints are received from engineering, the Purchasing department solicits bids from potential sources of supply. Quotations received are carefully reviewed and tabulated for comparison. The supplier's record with respect to quality, dependability, and price are important factors.

Negotiations with prospective suppliers often develop the need or desirability of discussion with the Production Engineer. Purchasing may submit recommendations with respect to tools and equipment, specification changes, availability of optional or better materials than specified. Other similar reasons may warrant changes in design or specifications without impairing quality, style, or utility. Purchasing also clears all patent questions with the legal department.

When contacted by Purchasing for reasons such as these, the Production Engineer must be prepared to make prompt decisions on requested or recommended changes, even to the extent of additional testing which may be required.

Favorable completion of satisfactory purchase negotiations depends largely on prompt and close cooperation of the Production Engineer in eliminating single sources because of patented design, expensive tooling needs, or other reasons. That's because of the ever-present hazard of late engineering releases or last-minute engineering changes. See Fig. 3.

The Production Engineer's help also may be needed if the source, after accepting the supply contract, runs into unanticipated production difficulties. To get delivery on the part and ensure end-product production on schedule, the source may require a design or specification change.

5. Material Control Department

After Purchasing has established sources, the Material Control department issues releases to the sources for quantities of materials and dates needed at respective plants. This department holds responsibility for an adequate and balanced inventory, including float and bank requirements, commensurate with end-product production schedules and

Fig. 3—Late engineering releases can throw a monkeywrench in Purchasing's negotiations with suppliers

materials availability. So follow-up with suppliers is another chief function.

Unsatisfactory performance by a supplier is reported to the Purchasing department for investigation and correction if and when necessary.

Close contact is maintained with the Traffic department to expedite material in short supply en route from source to maintain uninterrupted production at our plants. When necessary, Material Control must contact engineering for temporary deviations because of last-minute engineering releases or changes which might unnecessarily require air shipments from source rather than the cheaper regular rail or truck method. Sometimes an interim model engineering change may involve substantial obsolescence or commitment losses which might otherwise be needlessly incurred.

6. The Traffic Department

Traffic is responsible for establishing all transportation methods: rail, truck, air, and water routes. It includes incoming shipments of materials, interplant materials movement, and out-going shipments of finished products.

The Traffic department, collaborating with engineering and the container and shipping design section of the Standards department, develops methods of loading, boxing, and palletizing to insure safe arrival without damage for minimum cost.

This means maximum legal and safe loads for each shipping method. See Fig. 4. This sometimes requires design of special freight cars for such components as motors, hoods, and fenders. Methods of fastening parts to carrier floors might require special brackets or clamps. Engineering designs these either as a part of the finished product or component, or as a removable and re-usable part after shipment.

Export boxing has to be analyzed for salt water

shipping hazards and space limitations. Traffic also is responsible for proper classification of shipments, rate charges, and compliance with regulations of the ICC and other regulatory bodies.

7. Quality Control Department

Prime duty of Quality Control is to enforce quality standards specified by engineering. QC cannot authorize production to deviate from engineering specifications. This power is vested solely in engineering. But engineering cannot compel production to meet design and specification standards. That power is restricted exclusively to QC.

This department also develops all gages, fixtures, and tools for checking parts produced to designs and specifications established by engineering. QC calls attention to engineering jobs practically impossible to produce or needlessly specified within too close limits. Contact is made through the Master Mechanic with the Production Engineer for design or tolerance changes.

QC approves production samples from all sources before release for volume production. It also asks engineering for deviations to permit use of off-specified material. That's done during materials shortages or when strict adherence to specifications might shut down a plant and throw an entire labor force out of work.

8. Personnel Department

This group is charged with employee safety, health, and welfare. It must eliminate where possible, or minimize risks. Designs or specifications involving hazardous operations, use of dangerous chemicals, or other hazards are explored with engineering for correction.

9. The Spirit of Teamwork

Some manufacturing men seem to think that many engineers know too much about engineering and little, if anything, about manufacturing. And some engineers feel that the men who build the product, "or attempt to build the product," know too little about manufacturing and nothing about engineering.

Each group must avail itself of the other's knowledge and experience so both can keep pace with ever-changing conditions. When delays or failures occur, the blame shouldn't be passed to either engineering or production. When such things do happen, they should be fairly examined and responsibility placed where it rightfully belongs.

Dwight Morrow once wrote to his son: "The world is divided into people who do things and people who get credit. Try if you can to belong to the first class. There is far less competition." That is the ideal goal for both organizations.

Most material progress made by man since recorder history can largely be attributed to either a combined engineering and production man or to the engineering and production team. Certainly during this century it would be the team and not the individual.

Take the common nail. Demand for houses was as great after the Revolutionary War as it was after World War II. But after the Revolutionary War, the construction bottleneck was nails. Labor and lumber were cheap and plentiful. Nails were scarce, and very expensive when available.

Iron nails had been used before the Christian era, but they were hand made. Even during early colonial days, our forefathers sometimes burned old houses to salvage nails for new construction. Thomas Jefferson kept a dozen slaves busy forging nails to build his home, Monticello.

But Jacob Perkins, in 1795, engineered and built a machine that would produce 60,000 nails in one week. That machine broke the nail bottleneck.

Engineers and production men together have been breaking bottlenecks and contributing to man's progress through the centuries. Past opportunities have been great. Future opportunities will be greater.

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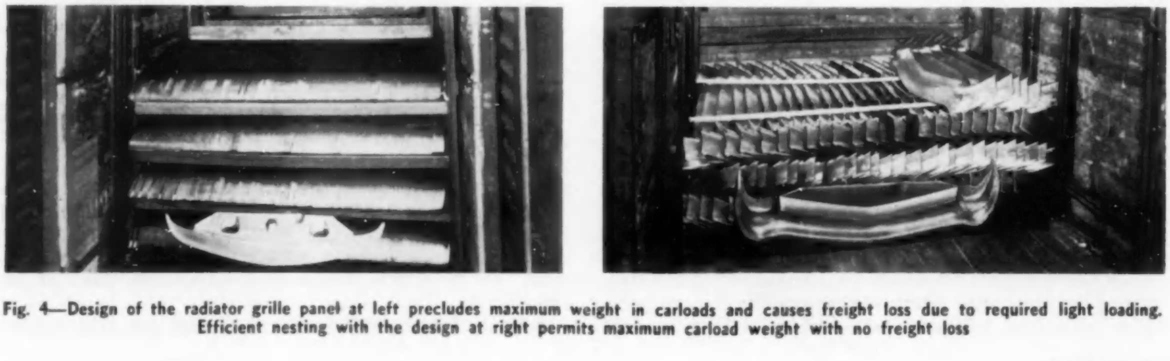


Fig. 4—Design of the radiator grille panel at left precludes maximum weight in carloads and causes freight loss due to required light loading. Efficient nesting with the design at right permits maximum carload weight with no freight loss

Design-Production Gap Can Be Bridged

R. J. Moran, Wright Aeronautical Division, Curtiss-Wright Corp.
Michael Field, Metcut Research Associates

Based on paper "Manufacturing Methods Development—Bridging the Gap Between Engineering Design and Production" presented at SAE National Production Meeting, Chicago, March 30, 1954.

BRIDGING the gap between engineering design and production is becoming increasingly difficult. Complexity of modern engineering design—combined with the need for low-cost mass production—has placed more emphasis on manufacturing methods development.

Take the case of jet-engine parts coming off the the drawing boards today. Many of them are so complex that existing production processes can't produce accurate enough pieces. Thus, the need for mass-producing such parts often necessitates development of new tools, gages, and methods.

A few specific examples will serve to illustrate how manufacturing methods development is carried out.

Problem:

Convert 40-lb Rough Forgings into 8-lb Finished Compressor Wheels

Fabrication of jet-engine compressor rotor discs posed many unique problems when first released for manufacture.

For one thing, the finished discs were 1½in. thick at the hub, but tapered off to only 1/16 in. at the outside diameter. (See Fig. 1.) For another, 32 lb of metal had to be machined off the 40-lb rough

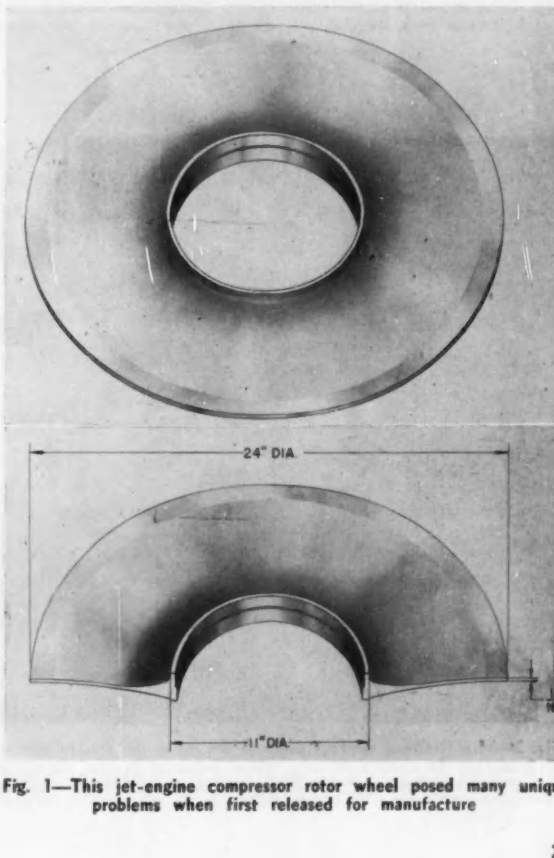


Fig. 1—This jet-engine compressor rotor wheel posed many unique problems when first released for manufacture

Fig. 2—In the early stages, vertical turret lathes were tooled so they could perform both roughing and finishing operations on the wheel shown in Fig. 1

forgings of AMS 6342 steel (heat-treated to 262-311 Brinell hardness).

These discs could, of course, have been made in small quantities on a tool room basis. However, they had to be produced in quantity . . . and immediately.

Therefore, it became necessary to prepare temporary methods and tooling to be used until the special machine tools on order were delivered and installed.

Vertical turret lathes were tooled so they could perform all the contour operations, both roughing and finishing. (See Fig. 2.) While this tooling was of a temporary nature, the sequence of operations was held as close as possible to the planned permanent setup.

Then, to meet the demand for greater output, standard engine lathes were equipped with hydraulic duplicators and were put to work performing the finishing operation. (This released the vertical turret lathes to do more roughing.)

Also, two Lodge and Shipley engine lathes were tooled so they could machine simultaneously both sides of the thin section of the discs. This arrangement closely adhered to the planned permanent setup, since the tools on order were also to turn both sides at the same time.

Many problems arose during this period that necessitated dimensional changes. This was anticipated. As these changes proved to be satisfactory, they were incorporated in the permanent setup.

To effect complete coordination of these developments, a special committee was organized which included members of the following departments: production models division of engineering, manufacturing, manufacturing engineering, inspection, and engineering materials laboratory.

At the same time, a pilot plant was set up to act as a proving ground for potential cost-cutting manufacturing methods and tooling. Here, by eliminating certain operations, combining others, and by

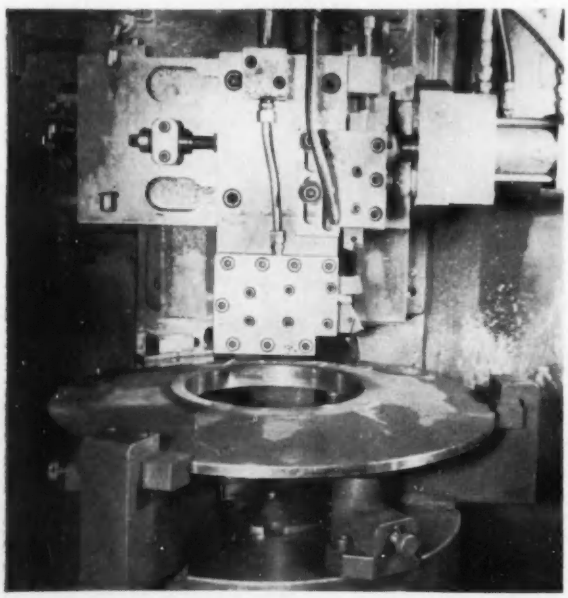


Fig. 3—Manufacturing methods development led to the present method of producing the compressor rotor wheel shown in Fig. 1. As shown above, the hub bore and hub faces are rough turned on a special vertical lathe

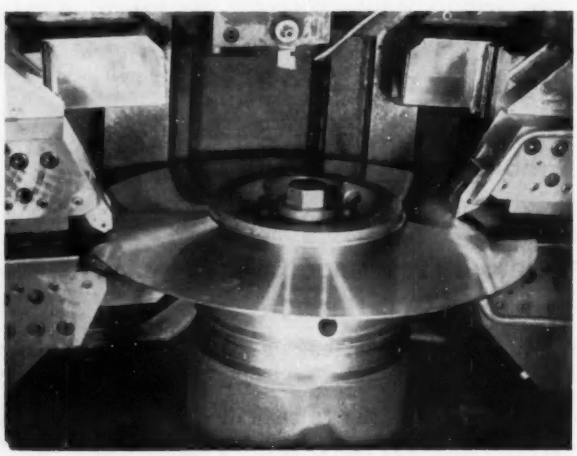


Fig. 4—A special contouring lathe roughs and semifinish-turns both sides of a wheel simultaneously

increasing depth of cut on the permanent tools (not possible with the temporary ones), machining time was reduced 20%.

All this led to the present method of producing these compressor discs. (See Figs. 3, 4, and 5.)

The rough forging is now held in a 3-jaw chuck on its outside diameter, and the hub bore and hub faces are rough turned on a special vertical lathe. (Fig. 3.) Carbide tools are used.

The disc is then placed on a special contouring lathe which has four tools whose paths are controlled by mechanical contouring devices. (Fig. 4.) The tools on the right-hand side of the machine rough-contour the upper and lower sides of the disc. Tools on the left-hand side semifinish-turn the same contours. (These tools trail the roughing tools by about ½ in.) A fifth tool on the vertical slide of the machine removes excess stock from the hub outside diameter.

The disc is then sent to a vertical turret lathe for finish-boring of the hub and finish-turning of the hub faces. Next, hub faces and outer flange faces of the disc are ground on a large rotary surface grinder, holding an accurate step dimension from the flange face to the hub face. The contour of each side of the disc is separately turned on a hydraulic tracer "T" lathe.

An improved and simplified contour gage for the side of the disc also grew out of this manufacturing methods development program. As shown in Fig. 5, this gage consists of a bar that has five flush pins. An indicator is moved on a V-track across the top of the bar. The difference in indicator reading from the top of the bar to the flush pin gives the error in contour.

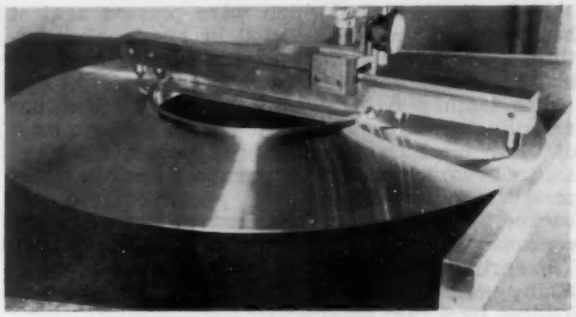


Fig. 5—This improved and simplified contour gage also grew out of the manufacturing methods development program

Problem:

Get a High Finish on the Airfoil Section of Compressor Blades

Manufacturing methods development was also applied to the problem of polishing the airfoil section of jet-engine compressor blades. (See Fig. 6.)

During the early stages of jet-engine development, tumbling methods gave satisfactory blade finishes. Later specifications, however, called for improved finish and specified that the scratch pattern run the full length of the blade from tip to butt.

Representatives of polishing machine tool companies were contacted regarding a machine to meet this requirement. They reported that they were in the process of experimenting, but had not come up with anything satisfactory to date.

This threw the problem squarely in our laps. Hand finishing was too slow to consider. With this possibility removed, trials were made using standard filing machines and column-like lapping fixtures located on the filer table.

The compressor blade was held in a special swivel jaw. It was then vertically reciprocated between

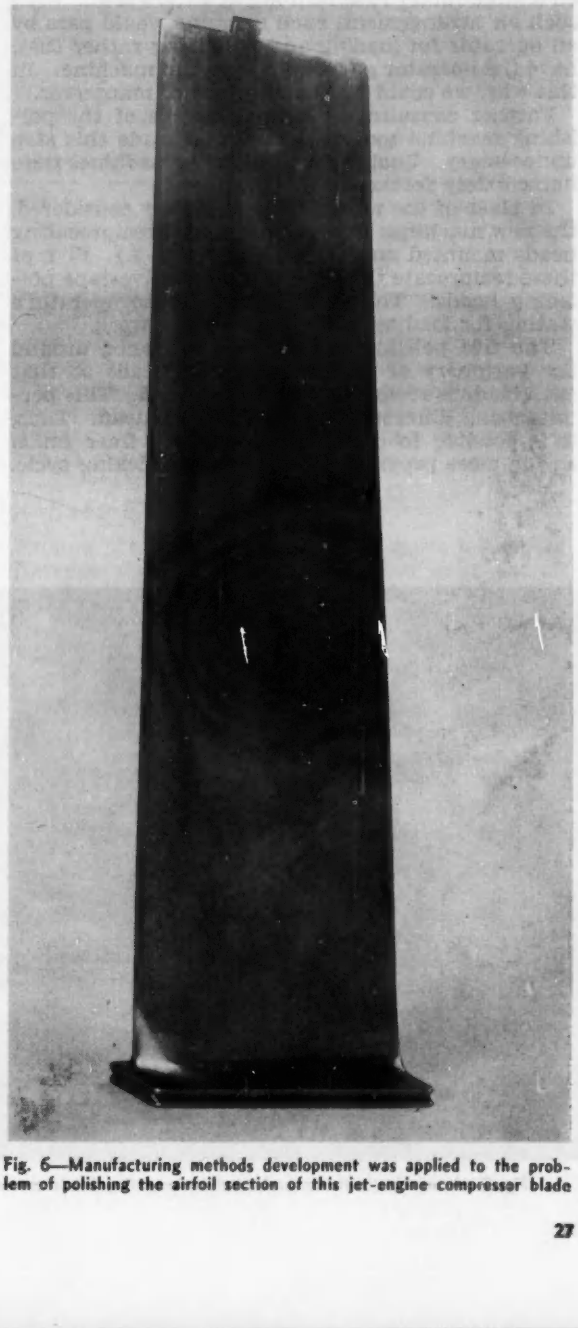


Fig. 6—Manufacturing methods development was applied to the problem of polishing the airfoil section of this jet-engine compressor blade

abrasive cloth strips which were pressed against both sides of the blade airfoil by the lapping fixtures. Swivel movement of the jaw allowed the blade to follow whatever twist was necessary.

The lapping fixtures consisted of two housings mounted directly opposite each other on both sides of the blade. These housings supported a spring-loaded arbor which applied the abrasive cloth under pressure to the blade. The abrasive cloth was backed up by molded-rubber inserts, formed to the concave and convex contour of the blade airfoil. The spring-loaded arbor was advanced to the polishing position and retracted for loading and unloading by a cam arrangement.

Results of trials with these machines were most gratifying.

We then considered installing several machines on a large rotary base running at a low speed. With such an arrangement, each machine would pass by an operator for loading and unloading rather than have the operator go from machine to machine. In this way, we could make better use of manpower.

Further consultation with engineers of the polishing machine tool manufacturers made this step unnecessary. Quotations on suitable machines were immediately forthcoming.

In place of the rotary table originally considered, the new machines have six horizontal reciprocating heads mounted on a table. (See Fig. 7.) Five of these reciprocate the work at the abrasive-tape polishing heads. The sixth is idle at the operator's station for loading and unloading the work.

The five polishing heads are positioned around the periphery of the reciprocating heads so that each blade is reciprocated at every head. This permits using different grit sizes at each head. Thus, it is possible to obtain a successively finer finish as the piece progresses through the indexing cycle. This was not possible on the original filer model which had only one abrasive polishing head.

Problem:

Woes Brought on by Switch from Stainless Steel to Ferritic Alloy

Change of material, too, often necessitates considerable processing development. The recent move at Wright Aeronautical to replace stainless steel with a low alloy ferritic high-temperature steel is a good case in point. Conversion from the stainless to the ferritic alloy brought about a number of problems in forming, heat-treating, welding, and surface protection.

Successful solutions to these processing problems were made possible only by close cooperation of the metallurgical, experimental, and manufacturing engineering departments. The metallurgical engineering group suggested and developed preliminary processing which was first tried out on the original units in the experimental shop. The results of this early work were then used as a guide by manufacturing engineering in getting the new material into actual production.

Actually, the best way to sum up things in the production area today is this: At no time should we feel that our processes are beyond further improvement.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

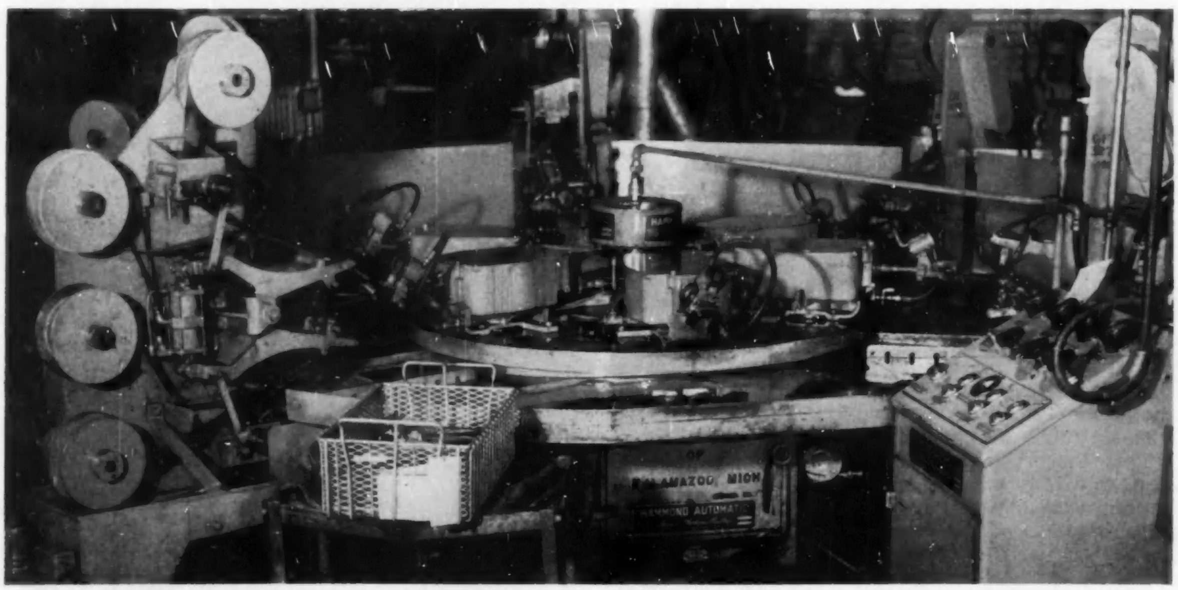


Fig. 7—A machine with six horizontal reciprocating heads mounted on a table was developed to polish the blade shown in Fig. 6

PRODUCTION DESIGN PARTNERSHIP

Five Steps To Ward Off Plant Fires

W. K. Ousley,

Vice-President, Boston Manufacturers Mutual Fire Insurance Co.

Based on paper "What Makes a Plant Safe?" presented at SAE Annual Meeting, Detroit, Jan. 12, 1954.

STUDIES show that all major industrial fires could have been avoided if five basic, simple rules had been followed. They are:

1. Use safe construction.
2. Install complete automatic sprinkler systems.
3. Provide ample water supply.
4. Train employees in fire prevention and protection.
5. Get top management support on fire safety program.

Most plants are not designed to cope with the unusual or unexpected. That's because the rarity of catastrophic fires lulls us into false security . . . the belief that "it can't happen here."

The backbone of quality control (what can happen may happen) applies just as well to plant protection. So first determine what *can* happen. Then follow the simple rules either to prevent it from happening if possible, or to insure that if you have a fire, it won't put you out of business.

DISCUSSERS

The men whose discussion is interspersed in this article are:

- ***John J. Ahern,*** Consulting Engineer, General Motors Corp.
- ***T. A. Dunlap,*** Assistant to the Director, plant engineering office, Ford Motor Co.
- ***George H. Miehls,*** President, Albert Kahn Associated Engineers and Architects
- ***David T. Shute,*** Assistant Vice-President, Liberty Mutual Insurance Co.

1. Safe Construction

From a fire standpoint, it doesn't make too much difference whether you construct your buildings of brick, steel, concrete, or wood. But avoid wooden walls and quick-burning boards on joists, roofs, and floors. Automatic sprinklers can adequately protect most construction.

Sprinklers are extremely reliable; but they do sometimes fail. So firewalls are needed as a second line of defense where there's something to burn. That's the only way to prevent total destruction from fire.

You must ask yourself this basic question: "How much of the plant can I afford to lose?" In considering this, disregard sprinklers because mechanical protection may be circumvented. You can lose that portion of the plant not separated by fire-resistant walls or open areas. There is no single answer to the maximum size of a fire area, but the following rules may guide you:

a. When contents are combustible, no matter what the type of building, a single fire area should not exceed 100,000 sq ft under the best conditions. Valuable concentrations of combustibles or hazardous operations will greatly reduce the permissible area.

b. Large areas are acceptable in non-combustible buildings with mostly non-combustible contents.

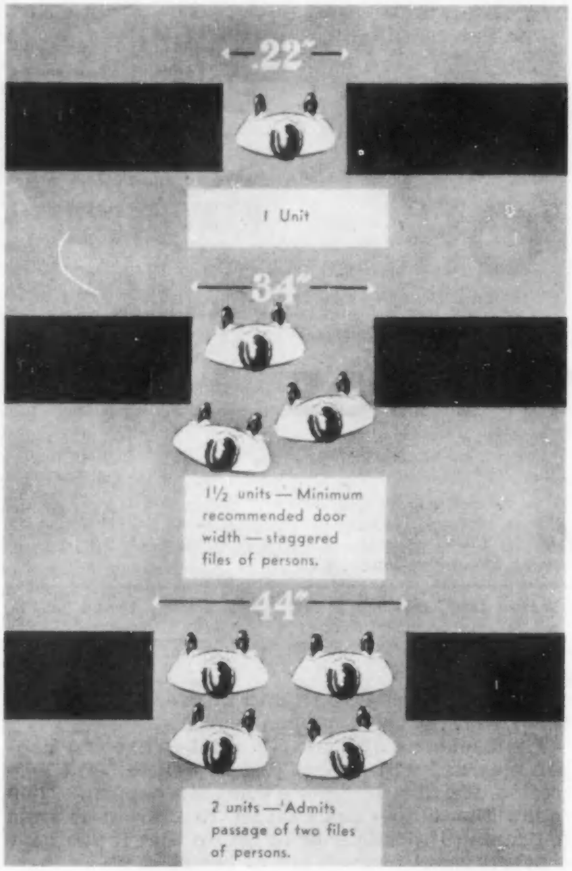


Fig. 1—This diagram illustrates the principle of the unit of exit width, which is the width necessary to permit passage of one person, without crowding, through a doorway or on a stairway

That's so only if concentrations of combustibles are segregated within fire-resistant walls.

c. In multistory buildings, floor openings such as stairs and elevators should be enclosed with materials at least as fire-resistant as the floors.

Here's another situation which you may have to anticipate. Your sprinklers are out of service and you have to fight fire with hose streams from the outside. Your fire fighting won't be effective if the building is much over 200 ft wide.

DUNLAP: We can't agree completely that safe construction requires fire resistant separation walls in areas exceeding 100,000 sq ft. We feel fire walls should be installed only when the hazard is comparatively great. And then they should be used only to enclose the hazard.

As a general rule fire walls are an unnecessary expense in three ways: (1) their installation cost, (2) the cost of production interferences, and (3) cost of additional floor space for aisles on either side of the wall.

MIEHLS: Today, fire walls can rarely be fitted to integrated manufacturing processes. But we can subdivide areas efficiently by baffles from roof to bottom chord of trusses. That helps control actuation of sprinklers to areas immediately affected.

Areas enclosed within such baffles would vary with hazards of the operation and with available water supply. They must be no greater than that which can be adequately served by water to all sprinkler heads in the area.

SHUTE: Plants should be so designed so that people can be quickly evacuated in case of fire. That calls for adequate exits.

Exits should be wide enough so that there is one 22-in. width, or unit, for each 60 persons to be removed vertically (by stairways) from the floor. Horizontal exits should be designed to provide one unit for each 100 persons discharged through them. See Fig. 1.

Experience has shown that exits should be near enough in case of emergency. For high hazard type of occupancy, the nearest exit should be no farther away than 75 ft. You can increase the distance to 100 ft for less hazardous locations, and up to 150 ft where approved sprinklers are installed.

In large plants, such as automobile and aircraft assembly plants, some points within the area are greater than 150 ft to outside walls. You can meet exit requirements in such cases with stairways down to tunnels under the floor. But these tunnels or passageways should be regularly used as exits so that employees will be thoroughly familiar with them.

2. Sprinkler Installations

Automatic sprinklers are your first and most important line of defense. They do more to protect plants and employees than any other single factor. They are always on guard, ready to go into action whenever fire starts. They strike at the seat of the fire, unhindered by heat or smoke. They cover the entire burning area. They eliminate unnecessary water damage because only the sprinklers that are needed will go into action.

Sprinkler coverage must be complete to be effective wherever there are combustibles. If fire burns unchecked in an unprotected area, resulting heat will open more sprinklers in adjoining areas than any reasonable volume of water can supply.

AHERN: It's wise to stress the value of a good system of water flow alarms on all sprinkler risers connected to a central station. This permits the sprinkler equipment to operate both as an automatic detection device as well as an automatic extinguishing system.

3. Providing Enough Water

Most fires in industrial plants are extinguished by eight or less sprinklers. That leads to a misunderstanding as to total volume of water required. It's not good fire protection to set up an arrangement that lets an occasional fire get out of control and destroy an entire building.

Average sprinkler demand over moderate combustibles is about one quarter gallon per square foot

of floor area per minute. So if sprinklers were called upon over 8000 sq ft of floor area, water demand would be 2000 gpm. Only the strongest water systems can supply this.

Highly combustible materials will require even more water. For example, rubber tires piled to a height of 12 ft would require about ½ gpm per square foot of floor area.

An adequate water supply will meet two requirements: (1) it will supply all sprinklers likely to operate for duration of the fire, and (2) simultaneously supply water used for hose streams. The usual hose stream discharges 250 gpm or more.

In many cases public mains alone will not provide all the water needed for fire protection. That's why elevated gravity tanks or pump suction tanks at ground level have become common at large industrial properties.

AHERN: Mr. Ousley mentions the desirability of ¼ gpm per square foot of floor space for a sprinkler system. This may be misleading for those unfamiliar with sprinkler operations.

Obviously it can't be applied to plants with areas of 1,000,000 sq ft or more of floor space. Using this measuring stick would call for an astronomical demand, beyond the capacity of any water system.

What this means is that we must estimate the maximum number of sprinklers which might be opened by one fire and then calculate our maximum demand on an average of 20 gpm for each head.

Very few industrial water systems are prepared to supply over 3000 to 4000 gpm. That means a supply of water for 100 to 150 sprinkler heads when allowance is made for extra demand from fire department hose streams, standpipe, and hose equipment. Figuring 80 sq ft per head, this means we are basing our protection on sprinklers confining the fire within 8000 to 10,000 sq ft of floor area. This can only be done by an effective combination of emergency roof ventilation and draft curtains or fire barrier partitions.

4. Training Employees

Personnel trained in safety measures will prevent most fires and accidents. They will also quickly control those fires that will start despite prevention measures.

First step in training for all plants is to organize fire squads of five or six key employees in each department. Make them on-the-job inspectors to report and correct fire and accident-producing conditions. Provide them with proper educational material. Teach them to use extinguishers, to practice good housekeeping, and importance of automatic sprinklers.

Plants with private hydrants and hose systems need trained men to use them quickly when needed. The fire squad men can also be members of the larger plant fire brigade. They should be familiar with the entire plant protective system, frequently drilled in handling a large hose stream, and assigned definite tasks in case of emergency.

Responsible maintenance men should make careful weekly inspection of safety and fire protection equipment to be sure it's kept in good working order. A thorough inspection, for example, will reduce the probability of inadvertently closed sprinkler valves. Each year accidentally-closed valves cause multimillion dollar losses.

DUNLAP: Mr. Ousley's rule on training people in fire safety is the first and most important one. No matter what kind of construction or operation you have, the better people are trained, the fewer fires will start and the better they will be put out when they start.

SHUTE: The training program should include a sound evacuation plan. People assigned to various details of this program should be:

1. The exit drill chief, who is in immediate command of all operations.
2. Area captains, who supervise evacuation procedures in their respective areas.
3. Exit guards, stationed at critical points along the exit path to see that evacuation proceeds in orderly fashion.
4. Searchers, to inspect rest rooms and other less commonly used places.
5. The inspector, who makes daily examinations of exits and alarms.
6. Substitutes, who may assume responsibility for any of the above positions in absence of the regularly assigned persons.

5. Getting Top Management Support

In the final analysis, responsibility for a safe plant rests squarely with management. It isn't enough to authorize the spending of money. Management has to see that interest in safety and fire prevention pervades the entire organization.

Responsibility for planning and coordinating prevention and protection must definitely be assigned to one or several individuals. Too often a fire safety requirement will be disregarded because those responsible for manufacturing object.

There need be no such conflicts, particularly if your fire and casualty underwriters can work with you in planning new facilities. Most difficulties arise in trying to apply safety measures to existing facilities. They often disappear when discussed in the planning stages.

AHERN: When pressure from the top for safe practices is equal to that for production, most of our safety problems will evaporate.

One other fundamental might be added to Mr. Ousley's list of five. That is to replace flammable materials with incombustible types. For example, modern machine shops use tremendous quantities of cutting oils, quenching oils, hydraulic oils, and flammable paints. Research already is coming up with nonflammable materials in these areas. If industry really wants it, truly incombustible metalworking is not too far in the future.

(Paper on which this abridgment is based is available in full in multilithographed form, together with the discussion, from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

It Shouldn't Have

MISCONCEPTION of common objectives has been the root of most hassles between Engineering and Production in the organizations I have known. Costly mistakes and resultant disharmony could have been avoided if both sides accepted this mutual goal: low cost of manufacture.

To achieve this, you need to shoot for two things: (1) simplicity in design and (2) coordination between Engineering and Production in design planning stages to prevent pitfalls in manufacturing.

The instances that follow are examples of the penalties paid when either of the two groups fell down on its responsibilities:

CASE 1: Too Late for a Remedy

One manufacturer I know in the automotive field decided to use a welded sheet steel housing for a finnicky mechanism instead of using a cast or fabricated design.

Pretty close tolerances were called for. So it was decided to process the sheet steel part on vertical automatic Bullards. These $75,000 machines can hold tolerances to 0.0005 in.

The job was tooled up and the plant went into production. The shop immediately ran into trouble. Even though the machine tool performed its operations within the prescribed accuracy, somehow inspection found the dimensions way out of line. Just by sitting on the floor over night, the parts went out-of-round by 0.020 in.

At this point, the company had too heavy an investment in machinery and tooling to turn back. It couldn't renege on promised delivery schedules because the customer needed the equipment. So the company had to struggle along as best as it could with the totally inadequate process, reworking and changing the machined housings . . . an expensive process at best.

Somehow Engineering and Production had slipped up in not anticipating the trouble. The company had to pay for the mistake throughout the life of this production program.

CASE 2: An Engineer Loses Face

One of my early associations with the automotive industry was with a car manufacturer. The engine plant and engineering department were at the opposite ends of town.

One day the engine plant received a drawing from engineering, and it was a "stopper." It was a new design for a connecting rod cap, with a curved dipper oil hole! Fig. 1 is a sketch of what it looked like.

This curved hole was supposed to pick up oil to lubricate the crank pin bearing. The drawing

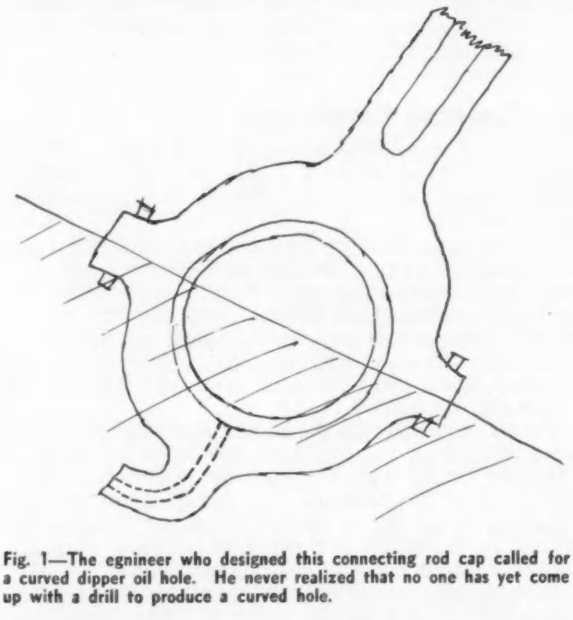


Fig. 1—The egnineer who designed this connecting rod cap called for a curved dipper oil hole. He never realized that no one has yet come up with a drill to produce a curved hole.

Happened

. . . anecdotes of production slip-ups in automotive plants which closer manufacturing-design teamwork could have avoided.

John G. Wood, Executive Consulting Engineer, New York Air Brake Co.

This article consists of ideas growing out of introductory remarks at a technical session of the 1954 SAE Annual Meeting, Detroit.

showed a full 90 deg turn from inlet side to outlet side of the hole. There just wasn't a drill made, then or now, that could produce a curved hole.

Naturally, the men in the shop lost no time in sending the drawing back to Engineering. The shop never held the engineering department in high esteem anyhow. This incident merely added fuel to the fire. And it took the designer of the curved hole a long time to live down his ignorance of manufacturing methods.

CASE 3: What Price Progress?

If there's any one thing that will drive production men crazy, it's design changes. In one situation that I knew of, changes were a pretty common occurrence, and not for the usual customer-requirement reason found in aircraft plants.

This particular company made a fairly complicated, but precise, mechanical unit. One day one of its customers received a shipment of 10 units. When the shipment was opened, the customer found that no two of the units were exactly alike as regards the component parts.

As soon as management received the customer's complaint, it confronted the chief design engineer with the situation. It was discovered that he kept pushing through design changes long after the start of the full production program. His reason: He wanted to pass on all improvements to the customer just as fast as he was finding them. It never dawned on him that making changes with gay abandon was wreaking havoc in the shop and in service!

CASE 4: Who Would Have Known?

At one time, a car manufacturer I was with used wood wheels with a steel rim. The rim was detachable and held the tire in place with five lugs. The lugs in turn were held by bolts.

The zinc-plated lugs were bolted in the shop with speed wrenches. Zinc tends to squeak because of friction. So when the squeak was reached, it was a good sign that the bolts were turned on tight.

One day the engineers decided that they didn't like the appearance of the bright zinc-plated lugs against the dark painted rim. They went to Parker rustproofing as a replacement for the zinc coating. The last operation in the Parker process was a hot paraffin dip, as a final protection for the Parker coating.

Engineering released the change to Parker rustproofing to the shop, and the Production Department put it into the works immediately.

After the first day's production with the Parker-treated lugs, the Production Department was at its wits end. Not a single wheel came through in acceptable shape. Each and every rim had collapsed. An investigation quickly disclosed the reason. The friction-producing zinc had been replaced with a wonderful lubricant in the form of paraffin. There was no resistance to the wrenches and they kept right on turning the bolts until the rims were squeezed together.

It seems that when Engineering had investigated the Parker process, it had not been aware of the final paraffin dip. A simple change of the torque setting on the speed wrenches eliminated the trouble.

Assembly Machines

IN-LINE machines—for the automatic assembly of major components—can make a substantial contribution toward our technological goal of reduced production costs and improved quality.

A general view of our first in-line machine is shown in Fig. 1. The basic mechanism of the machine is an over-and-under chain that is indexed past each of the loading and checking stations automatically. The parts of the condenser assembly are either hopper or stack fed into nests mounted on the chain.

After each part is assembled an automatic device checks to make sure it is in its proper position before the chain is cycled. If the part is out of position or is missing, the checker stops the machine and indicates by a flasher bulb which station is at fault. Fig. 2 shows finished ignition condenser assemblies being inverted where they are mated to hand-fed leads in a crimping dial. These assemblies are then conveyed on an incline conveyor to a second over-and-under in-line machine, which checks the condenser electrically, rejects and sorts the rejections, makes and assembles the connection clip, and welds it to the lead.

This first machine reduced the assembly cost of the condenser and the quality of the product was improved. The in-line construction of the machine fits well into a production plant layout.

Since there were many similar problems of assembly in the plant, a study was made of the adaptability of the in-line approach to their solution.

The results of the study were as follows:

1. The basic machine should be standard. As much of the machine and its auxiliaries as possible should be such that they could be remodeled or reassembled for other units in case of product redesign.

2. The overall length of the machine should be standard.

3. The index portion of the cycle time should be as short as possible to allow maximum dwell time for hand or machine operations.

4. The fixture mounting should be simple.

5. Maximum freedom should be available for the use of standard auxiliaries, such as welders, presses, and hopper feeds.

6. The construction should provide safe operator conditions.

The machine as standardized has three different track systems: over and under, narrow track, and wide track.

The wide-track horizontal machine is the most popular type. It is shown in Fig. 3. Auxiliaries may be mounted between the tracks or at any position outside the tracks. Hand and automatic operations may be alternated. The indexing drive unit is shown at the right. Running the length of the machine is a camshaft, an electrical conduit, and an air supply line, which serve the auxiliaries used on the machine. Connections may be made any place along these service units. Split cams are used on the camshaft for easy assembly and adjustment. The index mechanism is designed for smooth action. This is necessary for stability of the parts in the fixtures. If the index action is jerky, the parts will be dislocated or thrown out of the holding fixture. The dwell time must be as long as possible, consistent with a smooth index. This gives the maximum time for the hand or machine operations, which are performed on dwell time.

Although the index of the chain is fairly accurate, provision is often made for a closer location of the assembly with the auxiliary by use of the following methods:

1. Floating the work holding station.
2. Floating a nest in the station.
3. Floating the assembly in the nest.
4. Picking the part out of the nest for the operation.
5. Floating the tool used in the auxiliary equipment.
6. Floating the auxiliary equipment itself.

Fig. 4 shows a standard base with the guard panels removed. The standard electrical control panel is shown mounted on the drive section.

In-line machines have a fixed index time of 0.9 sec and a variable dwell time. The chain travel is normally 5 in. per index, but this can be varied. The standard machine is 14 ft in length. Normally, 75 fixtures are mounted on a standard wide-track machine. Production rates up to 1600 per hr have been maintained. Several years experience has indicated a low maintenance cost. Chain stretch, an anticipated trouble, has not developed as a serious defect.

Although originally planned as an assembly machine, the development led to a variety of operations

Contribute To:

• Reduced Production Costs

• Improved Quality

C. A. Nichols and W. A. Fletcher,

Delco-Remy Division, General Motors Corp.

Excerpts from paper, "Designing and Building High-Speed Production Assembly Machines," presented at SAE National Production Meeting, Chicago, March 30, 1954.

obviously not of an assembly nature. However, most of them are performed in combination with assembly operations. For example, a bushing may be assembled to a lever, the bushing reamed, and then further assembly operations performed.

The machines perform the following operations in various combinations:

A. Machining: drilling, reaming, tapping, milling, boring, and burring.

B. Press operations: making and assembling press parts, riveting, staking, piercing, trimming, and forming.

C. Joining: welding, hot upsetting of studs and rivets, soldering, and heat sealing of pressure-sensitive materials.

D. Packaging: printing and packaging.

E. Automatic feeding: hopper feeding of parts, feeding and driving screws, and applying sealing compounds and lubricants.

F. Inspection: weighing, sorting of parts, mechanical checks, and electrical checks.

G. Miscellaneous: burning and cleaning.

A typical combination of operations is used on the distributor circuit-breaker lever, where sorting, hopper feeding parts, staking, reaming, milling, hot upsetting, burning, and inspecting are performed.

Fig. 5 shows the group of four machines used to produce circuit-breaker levers. It illustrates several principles followed in the design and construction of these machines.

1. They are enclosed to the floor, protecting the working parts and facilitating good housekeeping. The floor can be swept close to the base.

2. All guards are of heavy, durable construction rounded for pleasing appearance and equipped with handles for easy removal.

3. All steel is either painted or plated. Tools handled by the operators are chrome plated. The fine finish impresses them with the value of the machine and promotes much pride in the equipment.

4. Receptacles are provided for all tools used by the operator or setup man, and are placed where needed. Both the tools and receptacles are bright plated.

5. Facilities for the personal use of the operator are provided. Bright-plated ash trays are placed in permanent positions at the operator's station. Chairs of proper height are provided when the machine is built, with shelves fabricated into them for the women operators' handbags. Foot rests are also built into the machine base.

Before a machine is designed and built, the necessity and economic justification for it is determined by the cost estimating department. This is done at the time the production method is being planned for a new product. The operations to be performed are selected by the estimator in consultation with the supervisor of the "in-line" department. If the performance of the machine would be improved by a product redesign, a conference is held with the product engineer. The cooperation of the members of this conference group has re-

These assembly machines reduced production cost and improved quality . . .

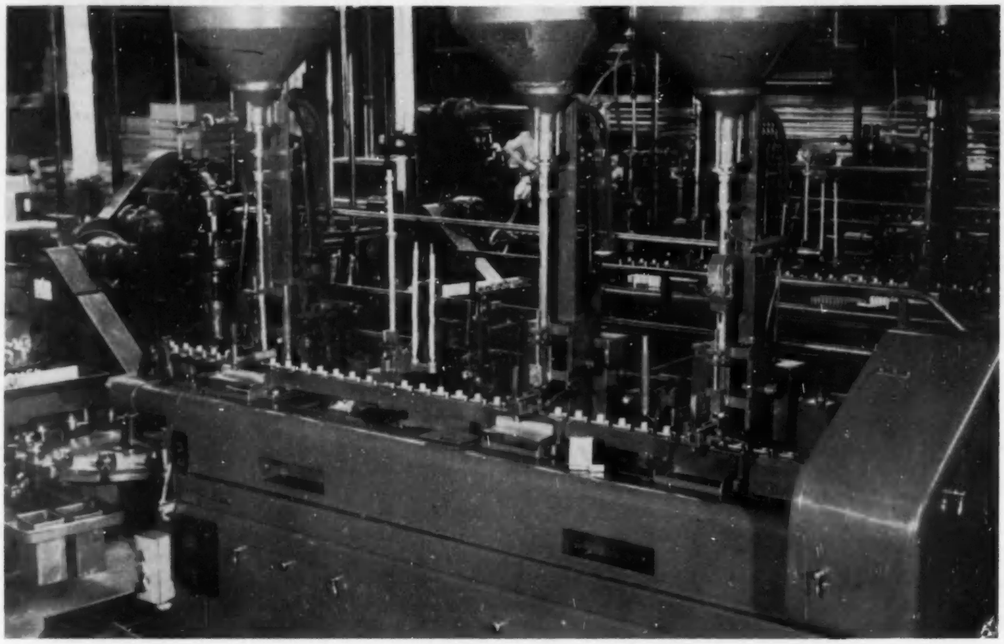


Fig. 1—First in-line machine to be developed

Wide tracks proved most popular track system

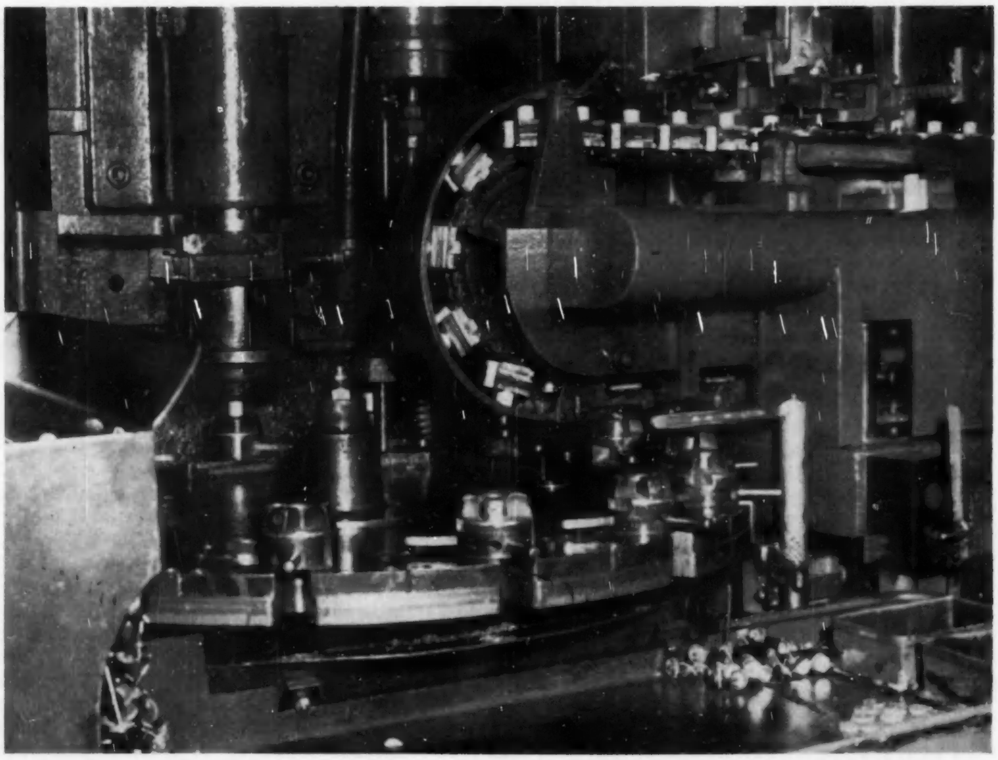


Fig. 2—Finished ignition condenser assemblies being inverted where they are mated to hand-fed leads in crimping dial

sulted in greatly increasing the effectiveness of the in-line machine.

The "in-line" department has its designers located in the same area as the shop where the machines are produced. This close contact between design and construction groups permits the trying out of ideas experimentally before the permanent auxiliary attachments are designed. Holding fixtures, which represent a substantial part of the cost of machine construction, are carefully designed with the cost factor in mind. The part of the working station fastened to the chain is standard, and is made up of welded press parts.

The "in-line" shop is set up to produce only those parts that involve development work. Bases and other standard parts are purchased. Thus, the skill of the department personnel is used entirely to solve the problems, and produce equipment that cannot be subcontracted. This has made possible the production of a far larger number of machines than would have been possible had we attempted to build the entire machine in our own plant.

Our "in-line" department draws heavily on the skills of our extensive production engineering department. These services include welding, press work, electronics, hydraulics, and the like. Close cooperation is also maintained with inspection, since, in many instances, inspection operations are performed by the in-line machines. Often, the auxiliary inspection equipment is provided by the inspection department, and built into the machine.

Automatic assembly requires greater uniformity of parts than hand assembly. It has often been proved that parts of higher quality, required for automatic assembly, may be produced at a lower cost because of lower scrap loss.

From the beginning of the study of a machine for a particular assembly, production supervision is in regular contact with the development. At the tryout stage production operators are brought to the department and production supervision aids in the training. Conferences with product engineers are held to consider changes of the parts to be assembled. These changes are judged by their values in improving both production rates and the quality of the product.

As the machine is "bugged out" the production rate increases until the machine is operating at its normal rate. During this time it is studied by the standards department to set the production rates. When the rate is agreed upon, the machines are moved to the production department.

Although not essential, it is desirable that a mechanic from the plant receiving the machine spend some time in the "in-line" department to become familiar with the equipment. If the mechanics from the "in-line" department were required to service the machines out in the production departments, their time available to produce additional new equipment would decrease as more and more machines were placed in use. The facilities to service these units properly are as necessary as those to produce them. The productive use of such equipment reduces labor cost but inevitably requires more skilled mechanics to service it.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

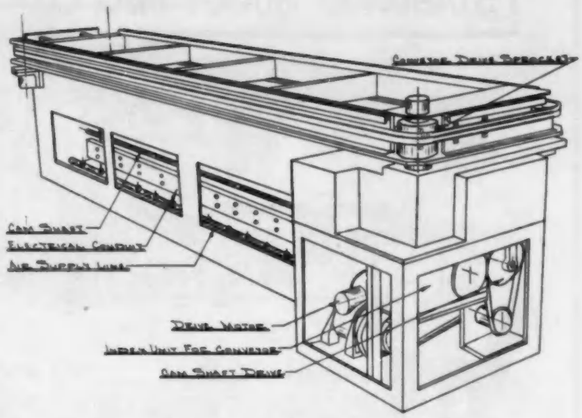


Fig. 3—Wide-track horizontal machine

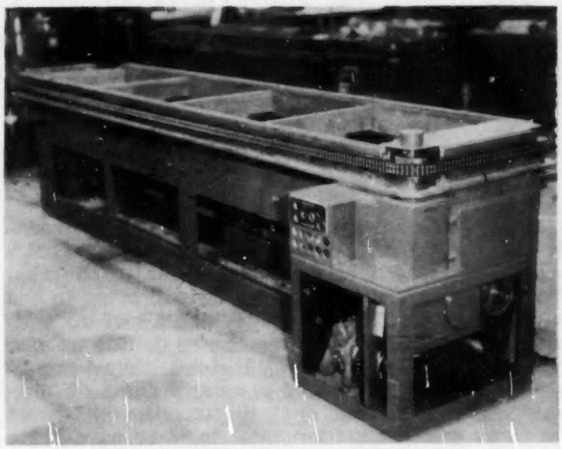


Fig. 4—Standard base with guard panels removed

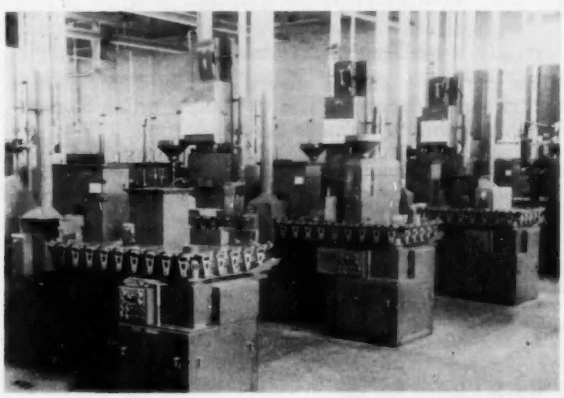


Fig. 5—Group of four machines used to produce circuit-breaker levers

MASS-PRODUCTION SHOPS can estimate their market well in advance. They need only feed this information into the production-planning hopper, but. . .

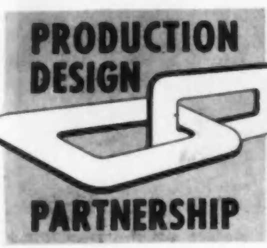
Men – Not Machines –

MEN, not machines, are the key to efficient operation of diversified-product job shops. That's because these job shops, unlike mass-production plants, don't know what tomorrow will bring in the way of orders. Therefore, they can't tool up with expensive special-purpose machines or line up raw materials well in advance. Instead, they have to rely on the judgment and resourcefulness of "human" machines. For that matter, the ability of designers and production men to work as a team can make or break this type of operation.

Before discussing in detail the all-important role of "people" in diversified-product job shops, let's see what such factories are up against.

Job Shop versus Mass Producer

The cartoons shown above clearly demonstrate the difference between the two basic types of company—job shop and mass producer.



Management of the Standard Buggy Mfg. Co. —a mass producer—can determine from market analyses how many buggies it can expect to sell within a given time. Then this information can be fed into the planning-production hopper . . . and out will come standard buggies.

Such a producer does have to plan each operation carefully and thoroughly—but only once for the predetermined time period. What's more, he can mechanize to the nth degree because his tooling and development program can be amortized over a large number of units.

The manager of the Custom Buggy Mfg. Co., on the other hand, doesn't have it so good. First, he must wait patiently for his salesmen to drum up an order. Then, once received, this order has to be custom-tailored all the way down the line.

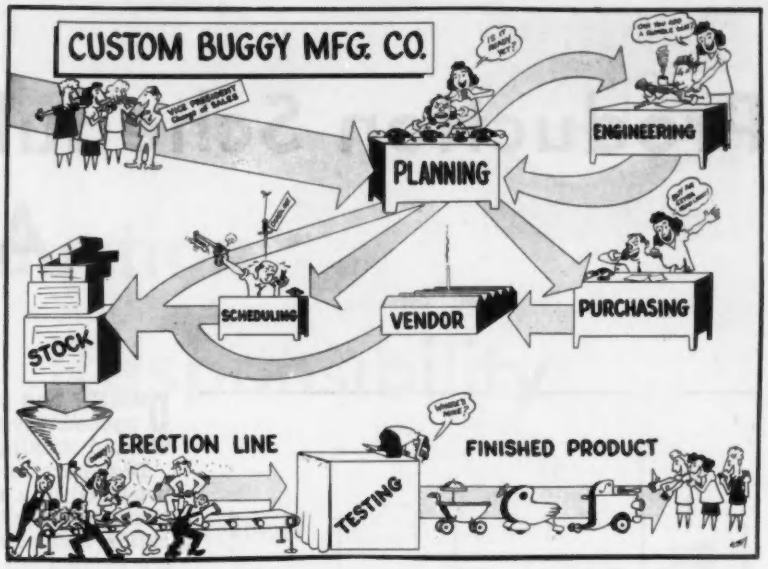
Needless to say, the small producer must shun expensive, special-purpose equipment. Also, unlike the mass producer, he can't get by with a planning system that rigidly outlines each step in the conversion of the customer's order to production of the finished product. Instead, his planning operation must be flexible. It must encourage the exercise of discretion by the people involved in the system.

Flexibility a Must

Flexibility, then, is the foundation on which any efficient diversified-product job shop must be built. And men—not machines—must form the pillars of this foundation.

The shop engineering departments, for example, must think in terms of selecting machines, designing tools, and planning layouts that offer maximum flexibility. Assignment of work to equipment in many short-run machining departments must be left to the discretion of the foreman (instead of

JOB SHOPS have to drum up orders catch-as-catch-can. Then each order has to be custom-tailored all the way down the line. With them, it's. . .



Make or Break Job Shops

J. E. Adams, Director of Purchasing and Planning, White Motor Co.

Based on paper "The Human Element—Catalyst in Proper Planning for a Diversified Assembly Operation" presented at SAE National Production Meeting, Chicago, March 30, 1954.

formal machine loadings set up by the scheduling department). Buyers cannot specialize on one given item. They must be competent to buy so-called standard materials, as well as procure special material on short notice.

In short, much of the detailed planning and programming for the diversified assembly line must not only be done by people, but performed by people rather than machines!

Supervisors of different functions must be thoroughly familiar with the problems of other departments . . . and make their decisions accordingly. The engineering department must design parts that can be made on existing plant equipment. Top management, too, must be close to the detail of the company's operations—so it doesn't promise impossible delivery dates.

Thus, while the diversified-product manufacturer must, like other companies, have a formal organization chart, he must depend far more on an informal organization chart—teamwork of people.

Cultivate a Relaxed Atmosphere

Now, what is the most important factor in stimulating the proper attitude, enthusiasm, and efficiency of these people? I believe it is the cultivation of a relaxed atmosphere that permits development of individual initiative and imagination.

This doesn't mean that one should cultivate and groom prima donnas. Rather, each man should be encouraged to develop his own strength and initiative as a part of the team, instead of being forced into a mold. Often the most competent people do their poorest work when rigidly regimented.

The higher echelons should have the ability to adapt themselves readily to the personalities of their assistants. This type of relationship leads to ideas . . . and ideas lead to successful, efficient operation.

Actually, when it comes right down to it, most of the problems in a diversified factory require "grass root" decisions. These are best made and influenced by "grass root" supervisors—men who have been taught to exercise independence of thought.

In short, the thing that's needed is leadership—a democracy rather than a dictatorship.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

Production Schedules Are A Joint

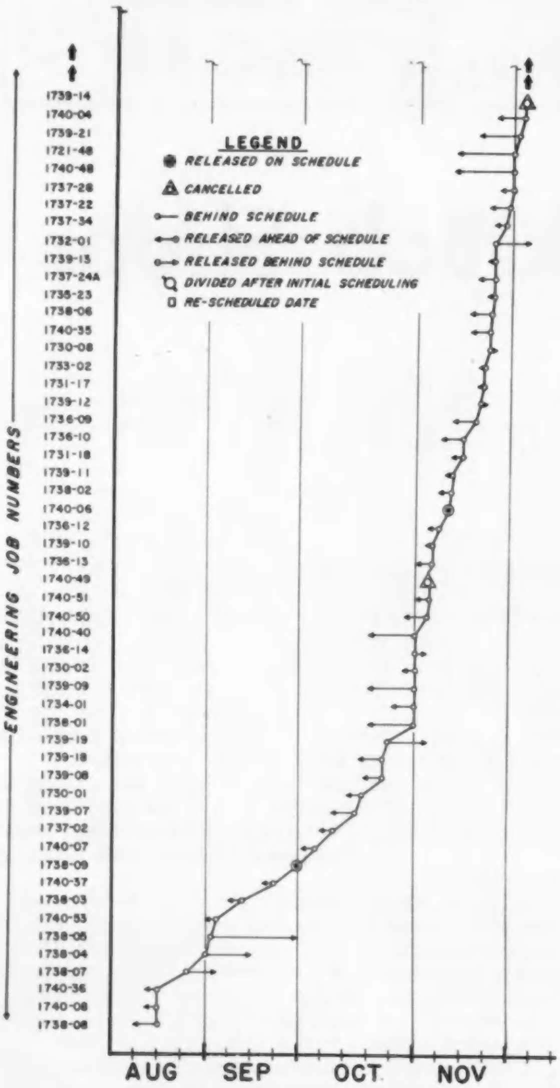


Fig. 1—Lockheed's project schedule curve

DESIGN and production engineers have joint responsibility in setting a brisk production schedule and sticking to it.

Designers have to deliver a design that can be produced in a reasonable length of time. Production men have to plan the details of economic fabrication and assembly, then see that the operations are carried out in the proper sequence and timing.

The more each group knows about the other group's problems, the more accurate the scheduling can be and often the faster the product can roll off the line.

Design Group's Part

Designers usually work backwards when the product is a complicated one like an airplane. Management figures out price and delivery dates on the basis of past experience and rough, preliminary proposals. Once price and dates have been agreed upon between management and the customer, the design group gets a set of deadlines for release of drawings for various units of the airplane. Design then goes to work to detail an airplane that will meet the customer's requirements and be producible within the quoted price and time interval.

The good designer doesn't wait until production planning figures out the man-hours it will take to make a particular part. He familiarizes himself with metal working processes so that he knows approximately how long a job will take and what it will cost. He balances this information against strength, weight, and other factors to evolve a design that is best from the combined standpoints of performance *and* producibility.

Good liaison between design and production will enable both groups to keep abreast of new production equipment on the market and the advantages it offers. Joint discussions will uncover ways new machinery can make the product better, faster, or cheaper.

Without close design-production cooperation, designers tend to avoid basing designs on advanced production equipment not already installed in the shops . . . and production men don't try to interest management in buying new equipment for which they see no use. The result is that the company doesn't get the benefits it might.

The design group must, however, be on guard against extending exploratory design using new methods and materials on the prescribed project too far. Work tends to go slower with new, unfamiliar tools and materials than with old. Gains

PRODUCTION DESIGN PARTNERSHIP

Design-Production Responsibility

Harold M. Harrison, Lockheed Aircraft Corp.

Based on paper "Over-All Problems of Producibility" presented at SAE Annual Meeting, Detroit, Jan. 14, 1954.

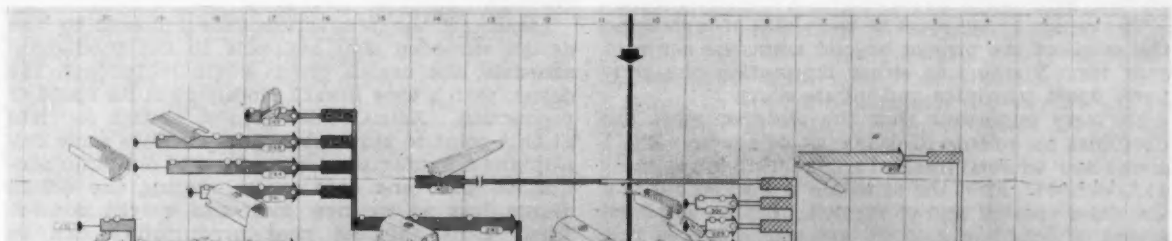


Fig. 2—Major assembly sequence chart

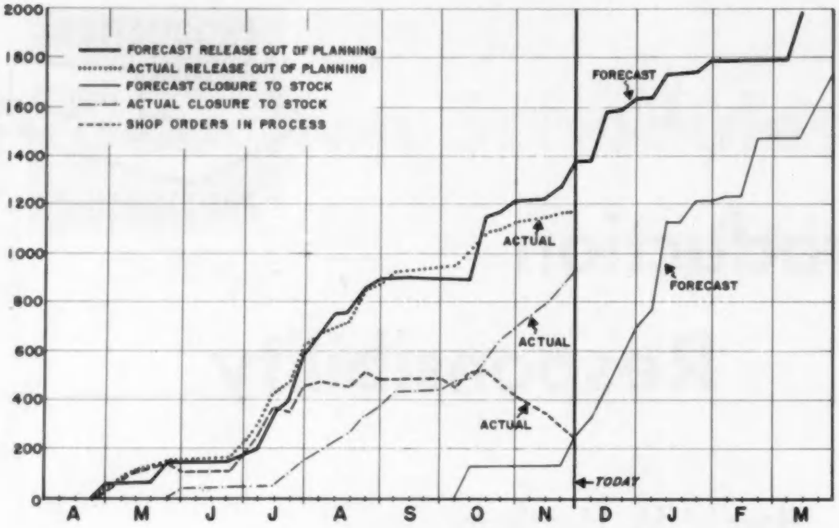


Fig. 3—Schedule for a mid fuselage. Solid lines represent dates that shop orders should be released from production planning and dates that parts should be completed and closed to stock. Other lines represent actual achievement. Chart shows position as of the end of November. Production is ahead of schedule but curve indicates it may not meet mid-January requirements

in ease of production and even in product performance must be balanced against the increased learning period they entail and the probable production run.

The design group must be wary also of increasing the scope of the project beyond what the contract calls for. Yielding to either temptation can seriously upset schedules and inflate costs.

It's very important that the designer meet the deadlines for release of drawings, of course. Fig. 1 shows how we keep track of engineering job releases at Lockheed. First the schedule is worked out and the dates spotted and connected. A job completed ahead of schedule gets an arrowhead and a line connecting it to its target-date circle. A job incomplete by the target date starts a line to the right of the target-date curve.

Any behind-schedule jobs are investigated.

As soon as a drawing is released, the production planning group makes out operations sheets and figures standard time allowances for doing the operations.

Ideally, if the production time required by the design exceeded that available in the production schedule, the design group would reapproach the design with a view toward modifying it for speedier production. Actually, it's almost always too late at this point to begin redesign. Perhaps some day airplane manufacturers can afford to maintain production time and cost control during the design stages just as we now maintain weight control. Then units showing poor producibility can be changed while the design is still flexible.

After production planning knows how long it will take to produce each unit, the next step is to work out the sequence. Fig. 2 shows how we chart major

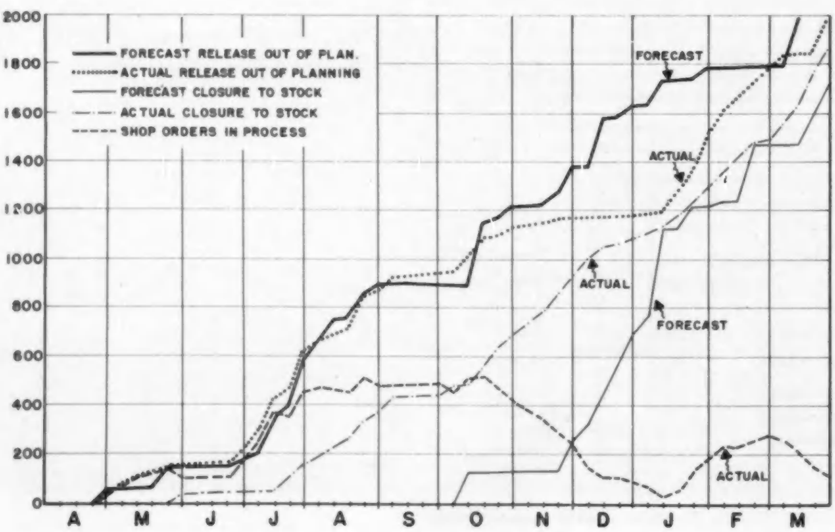


Fig. 4—Warning given by the control chart energizes production team to "bend that line." Chart shows that they did keep production ahead of schedule, although there were close calls during the second and fourth weeks in January and the fourth week in February. Chart also pointed out lags in production planning's work

assembly at Lockheed. Setting the schedule requires more than consideration of standard time allowances for the work listed on operations sheets. The schedule has to include time for tool proving spans, trial installations and fit checks, and training and introduction of new methods. Between the completion of the first and second airplanes there must be time for reworking and refining of the tooling, refining of assembly techniques, rectification of difficulties, and correction of minor drafting and engineering errors found in the proving of the first airplane.

Not even the schedule is perfect on the first try. Production experts check actual against scheduled output and make adjustments where necessary. The schedule that results is published, and output is continuously compared to it.

Figs. 3, 4, and 5 show two of the means Lockheed uses for depicting production performance. They are part of our routine periodic introspection. They help us to see at a glance what operations are heading for trouble.

For example, Fig. 3 showed at the end of November that actual release out of planning was heading for a collision with required (or forecast) closure to stock. Also, shop orders in process were at too low a value to permit many closures.

Fig. 4 shows what happened subsequently. The production team exerted great efforts to "bend that line." Actual releases change direction in mid-January in barely sufficient time to allow manufacture of the parts and their closure to stock on the favorable side of the forecast curve.

Fig. 5 is a pipeline summary for management. It is a composite of the primary interests of the operating heads. Postings are made weekly or biweekly.

Where production is ahead of schedule, the spread is colored in green. Where production is behind schedule, the spread is colored in red.

One thing that can put production deep in the red is changes. Both design and production groups should scrutinize very, very carefully every change that isn't absolutely necessary, especially changes introduced in the hope of cutting costs. Losses due to the general disruption and lack of learning tend to postpone cost recovery so that intended gains may never materialize.

Here's an example of what a change can do: Our company recently revised a major component of one model after 623 of the units had been produced. The first unit after the change required over six times the man-hours formerly taken. Not until we had produced 170 additional units did we get the time requirement back where it had been.

Production continued to speed up, and after 460 more units we made up our losses on the first 170. That is, we produced 630 units before we broke even on the change.

It worked out that the change was worth while in this case because we produced many more units after we broke even. On the first thousand units after break even, 400,000 hr were saved.

The story of a change doesn't always have a happy ending. Nevertheless, changes are inevitably required during the life of the model. It's up to design and production to work together to keep costly changes to a minimum and, wherever feasible, to impose them at lot change points.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

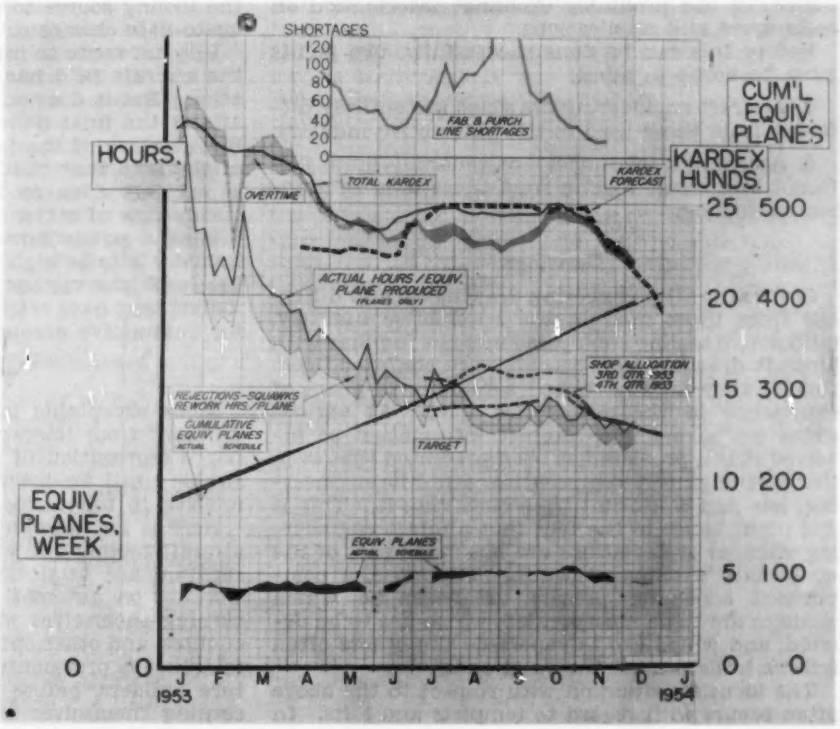


Fig. 5—This "pipeline summary" tells operating heads the things they are mainly interested in: (1) actual compared with budgeted hours per airplane produced, (2) rework hours per airplane, (3) scheduled versus actual airplanes produced each week, (4) accumulated scheduled and actual production, (5) actual number of men compared with forecast, and (6) fabricated and purchased parts shortages

Automotive and Aircraft Should Get to Know

DESPITE differences in assembly and engineering design procedures, automotive high-production and aircraft low-production tooling have many similarities. Therefore, tooling engineers from both industries can profitably exchange information on techniques and applications.

Before this can be done successfully, two points must be borne in mind:

1. Aircraft engineering drawings are entirely different from those used in the automotive industry.

2. Acceptable tolerances are generally quite different in aircraft tooling from those used in automotive tooling.

Drawings

Since aircraft engineering drawings are so different from those used in the automotive industry, automotive tooling shop personnel not familiar with aircraft drawings can become very confused, even though they may have had a number of years of experience in the automotive field. At various times we have found aircraft information so involved that a problem has been presented that even the tool engineer, representing aircraft engineering, has had a difficult time clarifying it. This is due many times to the fact that aircraft engineering changes or deviations are not made part of the up-to-date working drawings. Therefore, a complicated screening process to determine which changes are to be incorporated, which are to be deleted, and which are to supersede the others often follows to determine the valid ones.

The identical situation with respect to the above often occurs with regard to templets and lofts. In comparison with this, the automotive field maintains a steady flow of engineering changes or deviation data between the product engineering departments and their tool engineering divisions to enable the tooling source to be in direct contact with the up-to-date change or deviation at all times.

I do not mean to infer by the relation above that the aircraft field has created an impractical situation. But it does enhance delaying action, which affects the final delivery dates to a great degree. However, we of the job tooling field are cognizant of the fact that the high-geared automotive field is not left open to the constant harassing of a steady flow of major product changes while maintaining a steady flow of production. The aircraft industry is to be highly commended for its cooperation with the various job shops producing aircraft tooling that have originally been trained and geared for automotive acceptance.

Tolerances

Since acceptable tolerances are generally quite different from tolerances used in automotive tooling, a segregation of actual tool fabrication is desirable until an interlocking system of standards relative to tolerances has been devised.

Here is an example of experience building both aircraft tooling and automotive tooling before segregation has been affected. We have found men working on automotive fixtures and tooling concerning themselves with graticules, reticules, theodolites, and other optical equipment where a 0.0005 tolerance is prevalent, whereas aircraft jig and fixture builders, before segregation, have been concerning themselves with templets, spotting racks,

PRODUCTION DESIGN PARTNERSHIP

Tooling Industries Each Other Better

Jack Slean, Heidrich Tool and Die Corp.

Excerpts from paper "Automotive Tooling Experience with Aircraft Tooling and Manufacturing" presented at the SAE Annual Meeting, Detroit, Jan. 14, 1954.

and Keller part plasters, where a working tolerance of 1/64 or 1/32 is prevalent. Such a state of affairs brings about prohibitive cost in both instances, because each is concerning himself with tolerances not applicable to his product.

Following segregation we have found more cooperation, a better relationship between working personnel and supervisory personnel, higher quality, and greater efficiency, which in turn can be passed on to the customer.

By allowing a gradual infiltration of men from the aircraft tooling into the automotive tooling and vice versa, we have found a decided exchange of ideas or techniques being applied advantageously. This would only lead one to believe that, if an acceptable set of standards could be worked out, all parties involved would find greatly reduced costs the eventual outcome.

Successful Exchange of Techniques

Despite the lack of integration of techniques between automotive and aircraft tooling, there have been some successful applications of techniques from one industry to the other.

For example, a number of parts previously produced by router blocks, routing, and drilling are now being produced by low-cost blank and pierce dies, a method that has been greatly developed in the automotive field. This method previously was bypassed by the aircraft field, in many instances, because low production could not absorb the high-cost tooling method. The production of highly contoured parts, conducive to draw dies, originally developed in the automotive field, could not be justified for use in the aircraft industry because of the exorbitant costs. However, through the development of less expensive methods of producing draw dies, namely through the use of kerksite and plastics, a technique again has infiltrated from the automotive field into the aircraft industry.

The original method for setting details for automotive body fixtures was by the exclusive use of vernier height gages and scribers for layout of location lines in relation to centerline of car, front of dash, and normal top of frame lines. However, the aircraft industry developed a method of setting the detail by the use of four leveling screws to obtain the proper location of the detail and then locking it with four locking screws and pouring a cerromatrix shim back of the detail (Fig. 1), thereby giving it its permanent location. This reduces the number of man-hours spent in complicated layout and reduces the cost of the tooling product, effecting savings for the automotive industry.

One of the other major techniques having its inception in the aircraft industry was the use of photographic reproduction of lofts to produce shaped templets for model production, tooling detail location, and form reproduction. This method has been applied in the automotive field instead of the former complicated method of fitting and filing shape templets, and contour templets, to body draft layouts.

We have now touched on the infiltration of techniques from one industry to the other. Next, I would like to bring to your attention the possible use of a yet undeveloped idea in the automotive field —that of the aircraft use of optical equipment. One of the major tooling techniques is the use of optical tooling, which has been developed and is

Aircraft Tooling Ideas . . .

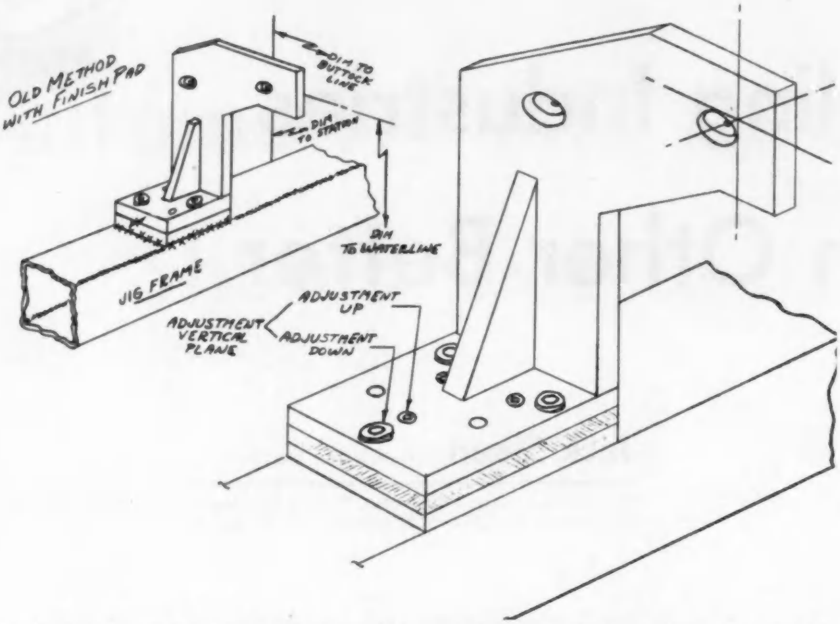


Fig. 1—Typical mounting of jig detail. Upper left—original method for setting details for automotive body fixtures uses vernier height gages and scribers; lower right—simpler and cheaper method developed by aircraft industry merely uses four leveling screws

. . . Can Pay Off In Car Plants

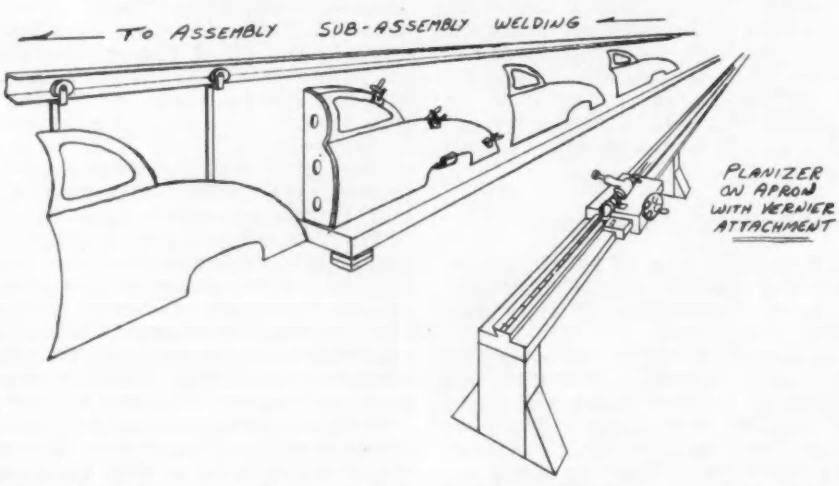


Fig. 2—Automotive body assembly automation, built, checked, and maintained by optical methods

now solely used by the aircraft industry, but which has a multitude of foreseen—but as yet undeveloped—uses in the automotive field.

This method of setting and aligning details and assemblies, if properly applied, can effect a substantial savings in automotive products. Its use in aligning of horizontal surfaces in relation to vertical or comparable horizontal surfaces, which have to be set visibly blind to one another, can be accomplished through the use of projected sight and the use of graticules and other optical aligning equipment (Fig. 2). This is one of the major tooling developments that, with the application of extensive study, could result in more economy and more efficiency in both the automotive and aircraft industries.

Our corporation, being one of the largest producers of aircraft and automotive tooling, has been sincerely indoctrinated with the need for more integrated use of one another's developments. One of the largest aircraft tooling projects was completed by our concern for use in the assembly of Boeing B-47 wings. These fixtures are approximately 25 ft high, 35 ft wide and 110 ft long, and weigh 80 to 85 tons (Fig. 3). Each fixture is three stories high, with a self-contained office. The original design of these fixtures by Boeing Aircraft was for permanent installation, thus, they were not conducive to moving, should decentralization become a necessity. With this thought in mind we redesigned the fixtures to enable us to machine each component complete to the setting of screw holes, dowel holes, and construction holes for self-alignment at the point of assembly.

We also maintained interchangeability of component parts and subassemblies to assure quick change over, should some mishap or damage arise in shipment, thereby avoiding appreciable delay. This was done by a method termed tooling for tooling. This tooling for tooling, at the insistence of the B-47 committee, is still retained in storage for use in the event of an additional accelerated aircraft program creating a necessity for the efficient B-47.

Concurrent with the redesign and the development of tooling for tooling we familiarized our people with the optical tooling method of precision setting and aligning of large fixtures. Our entire program moved at such a pace that sometimes paper work was several months behind. The first fixture was assembled complete in our Detroit plant to prove out our tooling for tooling and check coordination of tooling holes. The remaining fixtures were shipped in subassemblies for complete assembly at Kansas City. The trailing edge subassembly portion of the fixture was preassembled complete on a simulated installation, which was part of our tooling for tooling and consisted of 10-in. H columns set in concrete with additional columns to accommodate the optical tooling scopes and target reticules. This same method was later used for final inspection of the fixture by United States Air Force inspectors. By using this method, we were able to bring the trailing edge subassembly to a comfortable working height, also tilt it into a horizontal position, thus eliminating the necessity for station settings.

These were the major portions of the program. However, there were additional items such as contour skin drill fixtures involving, in proper location and size, approximately 17,500 holes per fixture with additional smaller tooling coordinated with the big jig for use on the final assembly of the wing such as spar locators, rib locators, and other items too numerous to mention.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

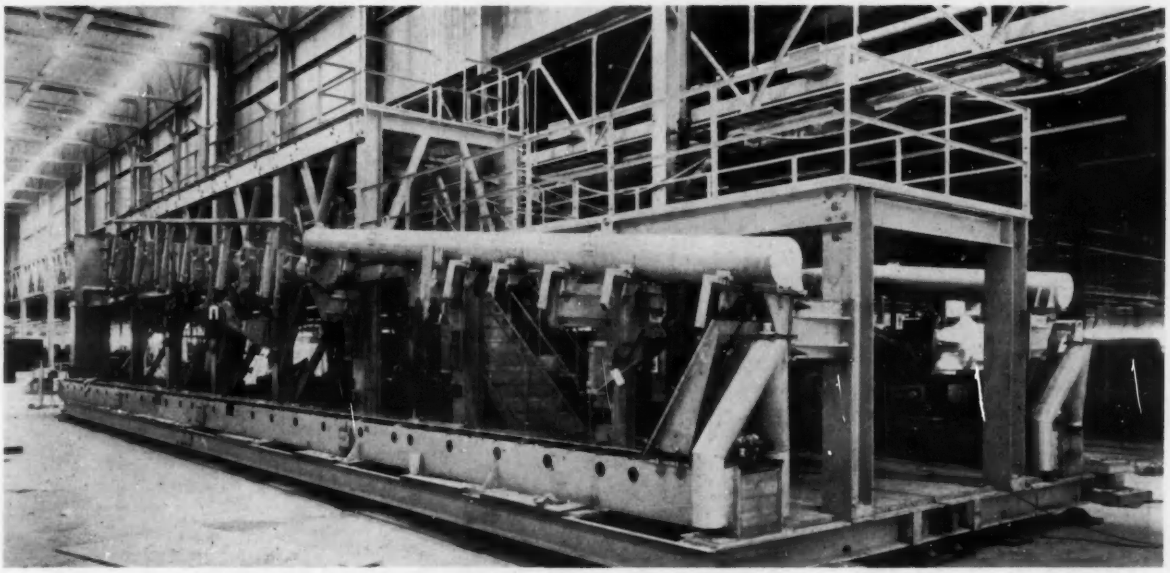


Fig. 3—Fixture used in building B-47 wing. This fixture has been designed so that it can be moved to a new location should decentralization become a necessity

International Harvester's

● **INTERNATIONAL HARVESTER'S TD-24** (shown below) is an agile giant in heavy construction, mining, land clearing, or pipelaying.

● **IN THE SIX-PAGE INSERT** section at right, SAE Journal photographically shows how this big tractor is manufactured and the thinking behind its production planning.

● **OPEN THE INSERT** and take the tour through IH's Melrose Park Works to which several hundred SAE members recently were treated. You'll see in photos . . .

1 . . . some of the TD-24's design features

2 through **15** . . . how the tractor is manufactured

Production of TD-24 Crawler

"IT's midway between a job shop and a mass production plant." That's what SAE members and guests were saying during their plant trip through International Harvester's Melrose Park Works, just outside of Chicago. The inspection tour, which focused on production of International Harvester's TD-24 crawler tractor, was held on March 31 as part of the activities of the SAE National Production Meeting.

Study of the TD-24 production line showed the dovetailing of engineering design with fabrication of this tracked vehicle. Two underlying conditions pretty well channeled the design of the TD-24 and its production programming, SAE visitors were told.

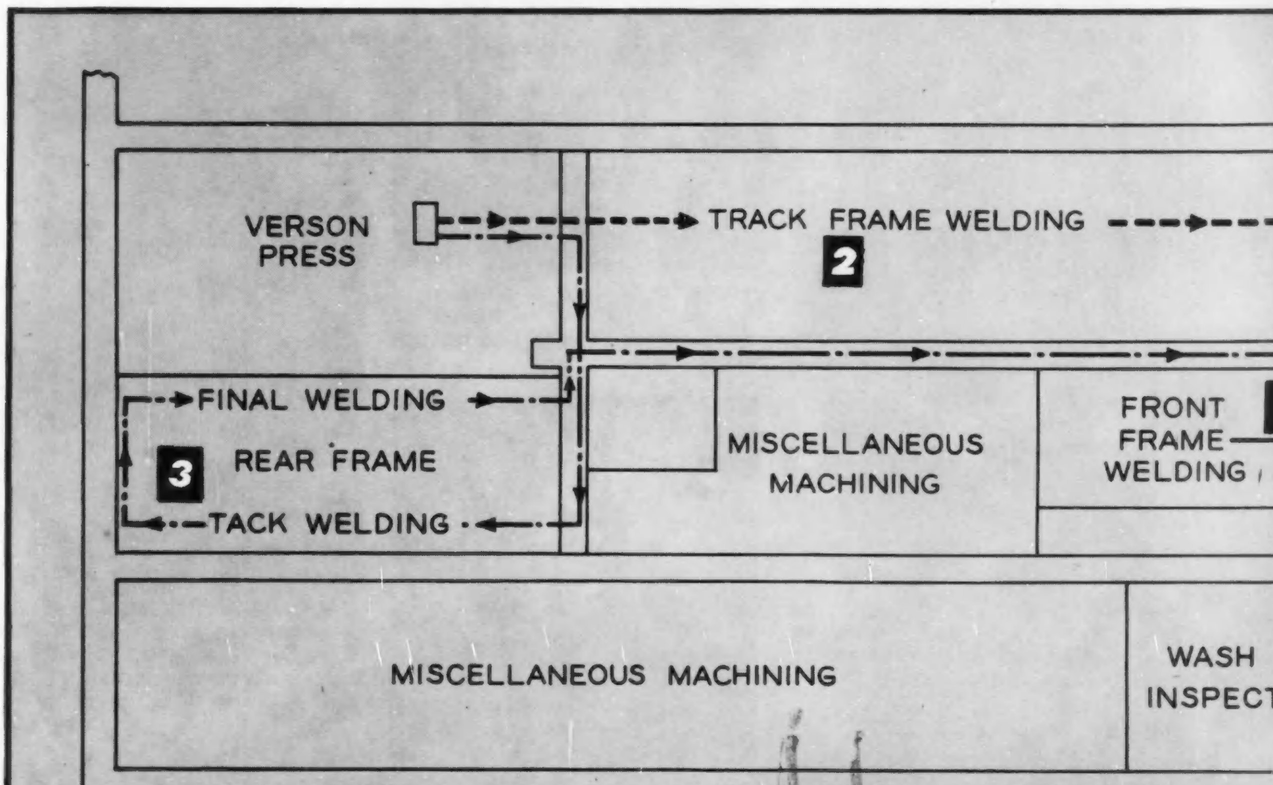
1. The vehicle is a hefty, hard-working behemoth. It weighs 20 tons and is one of the largest production crawler tractors built today. (One excavating contractor said, "We used to blast rock. Now we just plow through it with a TD-24.")

2. The vehicle is produced in limited quantities. The Melrose Park Works has been equipped to produce about five TD-24's per day.

These two conditions, plus a competitive bogie of a $20,000 price tag placed on the machine by management, brought about lots of compromises between engineering and production.

For example, the TD-24 was initially designed with a cast steel final drive housing or rear frame. But immediately after World War II, when this crawler made its bow, foundries couldn't produce such items at a reasonable cost. Welded forgings and plate looked like a more practical answer, and that's how the rear frame is being produced today.

Other factors also threw the balance in favor of



SCHEMATIC OF PRODUCTION FLOW OF TD-24 CRA
INTERNATIONAL HARVESTER'S MELROSE

Tractor Demonstrates Close

welding over castings. First, IH production engineers felt that welded construction would suffer fewer physical imperfections than castings. Second, the sizable castings needed would pose a storage problem. Third, the welded steel housing lends itself readily to repair in the field.

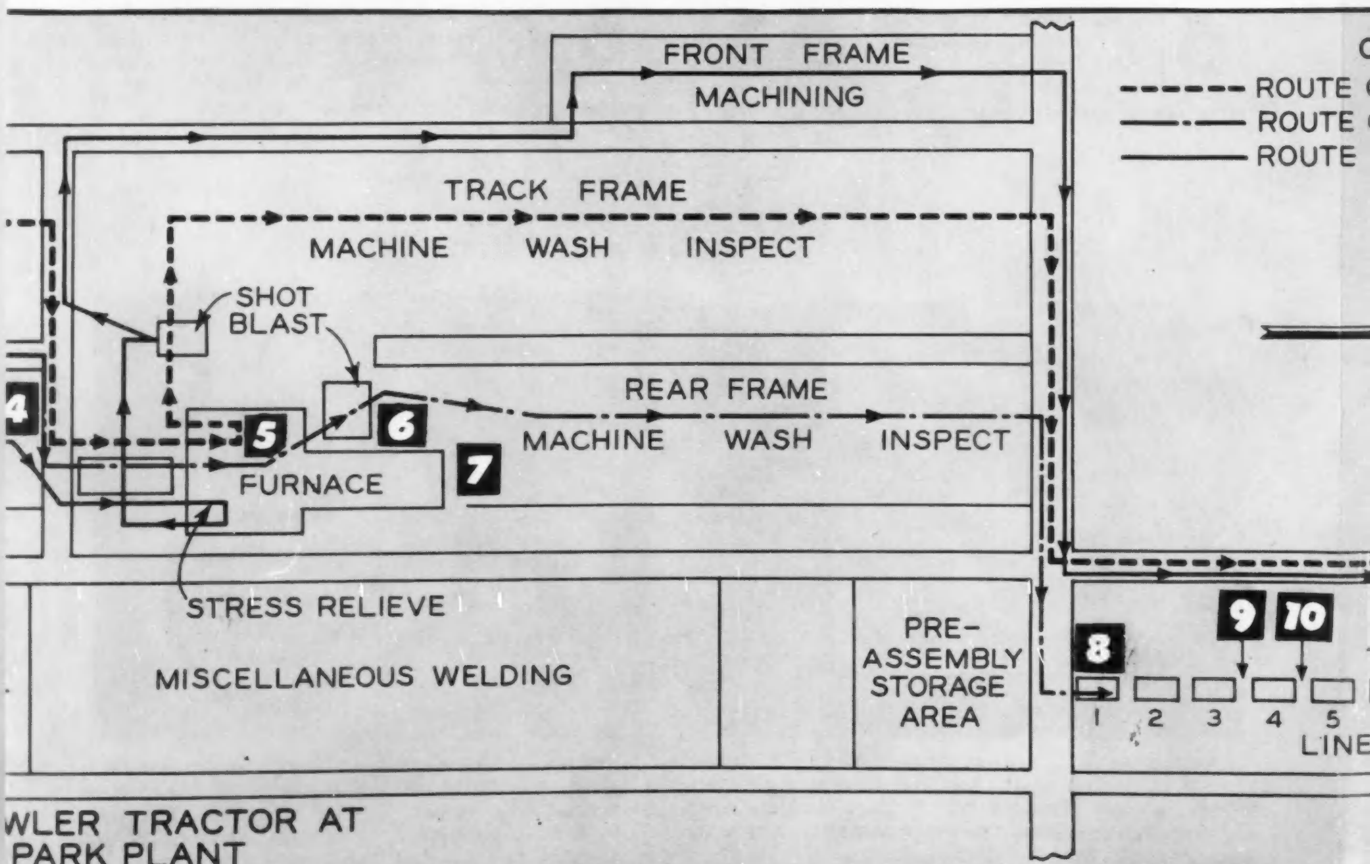
The original design also specified coil springs in the track frame assembly. Since such springs would necessarily be extremely large, the cost would have been prohibitive. The compromise which resulted specified Belleville-type springs in the production model.

The TD-24 was the first crawler tractor ever built with hydraulic steering and speed controls. That called for a rather complex hydraulic system. Normally, many parts of such a system are lapped and precision-fitted. But in the TD-24, the hydraulic systems have interchangeable parts. This was possible by IH production and design engineering. It's an important concession to practical serviceability of the tractor.

Production-design compromises also had to be made on the large, heavy-duty synchromesh transmission—an innovation in crawler tractors. Components such as synchronizers were unusually large. Manufacturing men had to devise ways of producing these components economically, and engineering had to design within definite space limitations.

Since design here was of paramount importance, production had to adjust its machinery to the problems design presented.

Machine tools shortages immediately following World War II required design changes to permit use of existing machines. As time went on and machine tool availability improved, minor engineer-



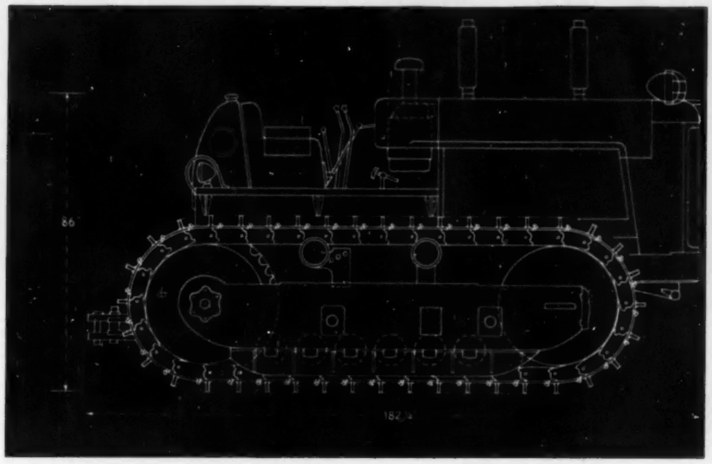
Manufacturing-Design Ties

ing changes were made in the light of field reports and engineering experiences.

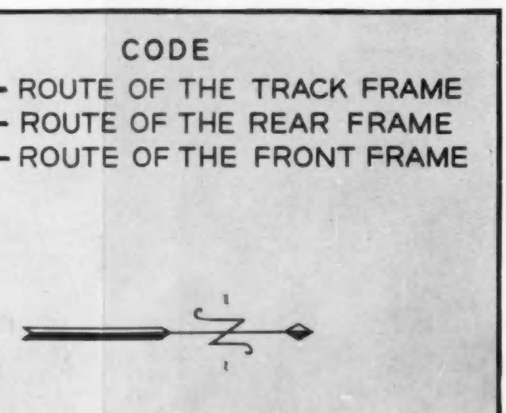
However, the low volume production ruled out heavy investment in single-purpose machinery. That's why the SAE visitors found numerous radial drills and saw cases where one machine tool performed several operations.

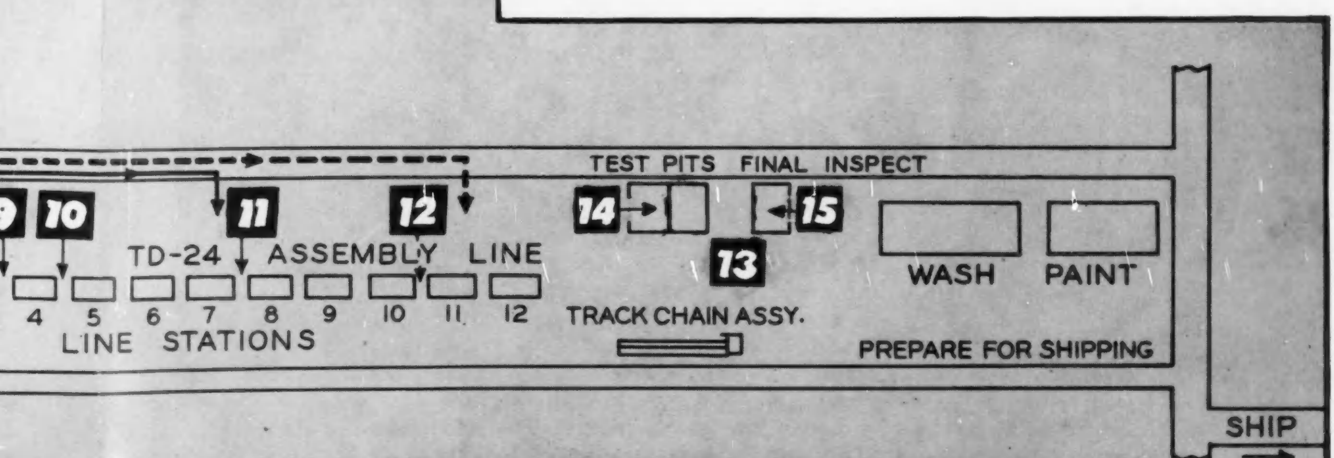
The SAE group also was told that IH was unable to take the same materials handling approach with TD-24 production as they normally do. That's because it's harder to stack and manipulate big parts. Materials handling problems have been eased wherever possible by regrouping machines.

Shown below is the flow diagram and layout of the TD-24 production routing. Photographs of individual production operations which follow are spotted as to their relative location in the production line.

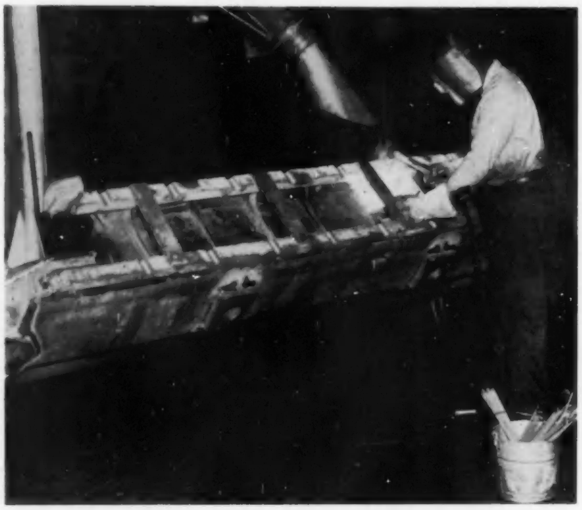


1. The TD-24 crawler tractor is heavier, longer and higher than its "Older Brothers." To see how this earth-moving brute, weighing more than 38,000 lb and consisting of more than 25,000 different parts, is put together, see the pages on the back of this gatefold insert. Circled numbers on the production layout below identify the locations of the operations pictured on the back of this insert



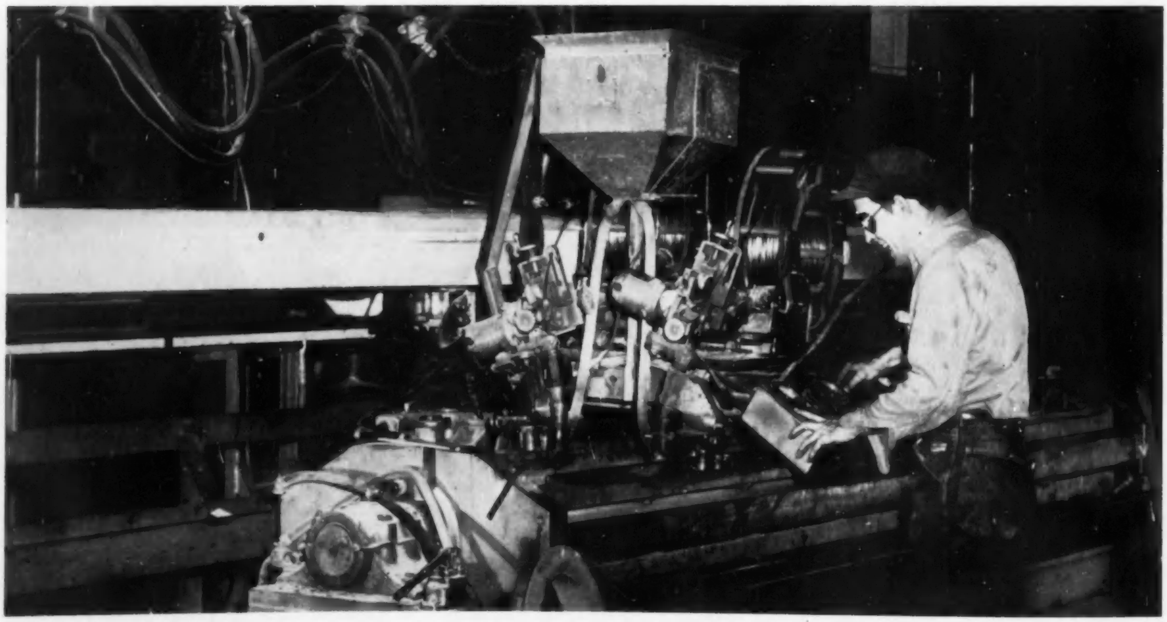


How International



2. Welding plays a big part in the TD-24's fabrication. The track frame here is going through final welding operations. It is built up of ½-in. steel plate and the completely welded assembly includes the track frame diagonal brace

3. The final drive housing is one of the main components around which the tractor is assembled. More than 200 lb of welding rod go into putting together its 50 forgings and steel plate parts. Welding operations are performed by hand on a positioner



4. The tractor front frame is welded automatically by submerged arc on a machine designed by International Harvester engineers. The longest weld on the main frame is about 100 in. The machine travels some 13 in. per min and each welding cycle takes about 10 min

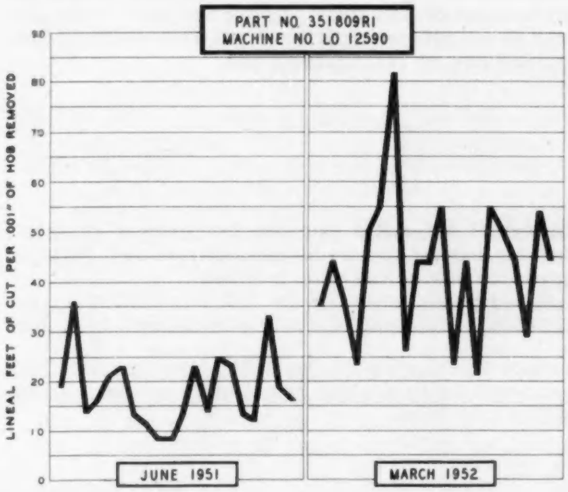
Statistical Controls Lengthen Life of Cutting Tools

W. H. Seacord and F. L. Helmel,
Mechanical Engineering Research Division, International Harvester Co.

Based on paper "Statistical Control Methods as Applied to Cutting Tools" presented at SAE Annual Meeting Detroit Jan. 12, 1954. (Paper is available in full in multilithographed form from SAE Special Publications Department at 35¢ to members, 60¢ to nonmembers.

INTERNATIONAL Harvester has instituted statistical control of gear hobs, milling cutters, broaches, form tools, and other cutting tools in a number of plants. In each case, the controls have saved money.

Principal advantage of controls is that they distinguish abnormal variations from normal variations. They show up differences in performance of individual tools, machines, operators, and even in the products of different tool manufacturers.



When performance is abnormally low, tool engineers look for causes like hard stock, substitute materials, or tool abuse. After the diagnosis, the cure is easy.

Abnormally good performance is investigated, too, to see if conditions can be duplicated.

The chart shows what can be done. When we started the program on gear hobs, no one knew for sure how much stock should be ground off in resharpening. The tool grinder usually ground until no evidence of prior use remained on the hob. For the month of June 1951, just before controls were instituted, only 17.57 lineal feet of gear teeth were cut per 0.001 in. of stock ground from hob teeth.

Nine months after statistical controls went into effect, the figure was 31.44 ft. The controls showed that the old bogies for the number of gears cut per hob shift were unnecessarily low. Many hobs were returned for resharpening before they were completely dull. Grinders tended to grind all hobs sufficiently to sharpen the teeth of the dullest. So in most cases, grinders removed too much stock.

Analysis of the causes of the fluctuations pointed the way toward further increases in the number of lineal feet cut per unit of hob.

Tool engineers in one plant increased hob life

30% merely by controlling the amount to be removed in sharpening.

The plant whose experience is charted reported statistical control of hobs alone saves $30,000 annually.

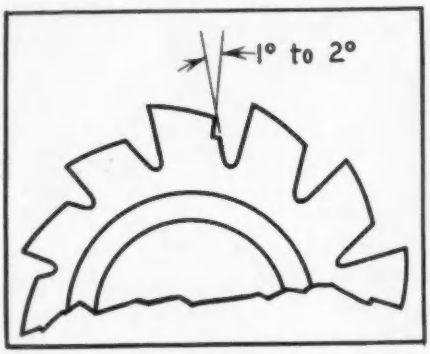
In another plant, inserted blade milling cutters were put under statistical control. Afterwards, grind was better . . . less of the blade was ground away . . . and fewer blades were broken. Cost per product piece went way down. Before the system had operated a year, the plant was able to transfer two shop trouble shooters to other duties because there were so few troubles with cutters.

All of the plants controlling perishable tools statistically report that the system reduces tool grinding time. This, of course, reduces plant overhead. The plants report also that research engineers can find and correct troubles faster—which leaves them more time to develop new tooling.

International Harvester's statistical control systems vary from tool to tool and from plant to plant. But everywhere, the savings in tool cost per unit of end product have convinced management that the systems are worth the extra paper work. The systems have fitted in smoothly with existing controls and have not required an increase in manpower.

The statistical control methods were developed by committees of people at plant level whose daily job and main interest is the control and use of perishable tools. Their objective was to develop control methods to reduce overall tool cost per unit of end product produced. Certainly the committees succeeded in attaining this objective.

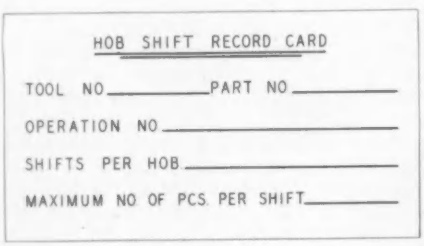
The pictures and text below show how one I-H plant controls gear hobs.



NEW HOB starts out in Tool Control Center, which notes hob manufacturer's hob serial number, grinds flat 2-deg rake on back of first full tooth, and measures tooth thickness.

Tool control center also makes provision on the hob for measuring tool life and indicating amount to be ground off in resharpening operation.

Center has control of each hob from time it is received in the plant until it is completely worn out.



HOB SHIFT RECORD CARD

TOOL NO ________ PART NO ________

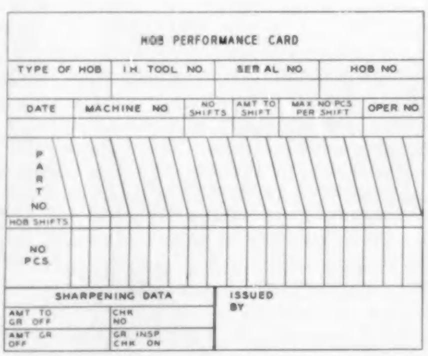
OPERATION NO ________

SHIFTS PER HOB ________

MAXIMUM NO OF PCS. PER SHIFT ________

HOB SHIFT RECORD CARD bears information on best practices as determined by a tool engineer. Tool crib attendant has Hob Shift Record Card for each part number.

When hobbing operator turns in dull hob for sharp one, he tells crib attendant the part number and operation number of the piece to be hobbed. Attendant copies from the appropriate Hob Shift Record Card the number of hob shifts, amount of each shift, and number of pieces to be cut per shift onto the Hob Performance Card attached to the new or resharpened hob.



HOB PERFORMANCE CARD

TYPE OF HOB	I H TOOL NO	SERIAL NO	HOB NO

DATE	MACHINE NO	NO SHIFTS	AMT TO SHIFT	MAX NO PCS PER SHIFT	OPER NO

PART NO

HOB SHIFTS

NO PCS

SHARPENING DATA		ISSUED BY
AMT TO GR OFF	CHK NO	
AMT GR OFF	GR INSP CHK ON	

HOB PERFORMANCE CARD is guide for hobbing operator. He follows its instructions as closely as hob performance permits. If necessary, he shifts hob before card requires.

High or low, actual performance of the hob is recorded on the card by the operator. Abnormalities are investigated by a tool engineer.

When the operator has used up all the shifts, he returns the hob plus its Performance Card to the tool crib and draws out a sharp hob bearing its own new Card.

HOB RECORD

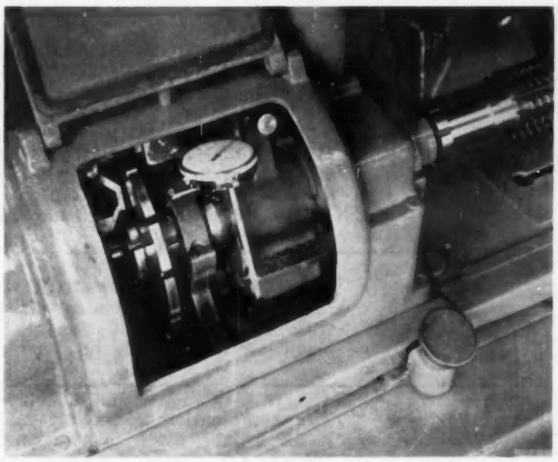
TOOL SERIAL NO.________ HOB NO.________ VENDOR________ IH TOOL NO.________

	DATE	PART NO.	MACH. NO.	MAT'L	HARD-NESS	NO. PCS.	HOB SHIFTS		PCS. PER HOB SHIFT	READ PRE-GR.	READ POST GR.	AMT. TO GR. OFF	AMT. GR. OFF.	LIN. FT CUT	GRINDER CHK. NO.	REMARKS
							OK	REJ.								
1																
2																
3																
38																
39																
40																

HOB RECORD CARD is tool control center's history of a particular hob. When dull tool and its Performance Card are returned to tool crib, information from card is posted on Hob Record. (Hardness is entered only in case of unfavorable hob performance.)

Tool engineer reviews Record Card periodically for evidence of abnormally good or poor performance. Performance Card is retained for a month or so, in case tool engineer needs its more complete data.

Dull tool is checked with a toolmaker's microscope to determine the amount to be ground off in sharpening. Amount is recorded on a new Hob Performance Card attached to hob. Hob and Card then go to grinding department.



DIAL INDICATOR mounted in the head stock of this No. 4 Barber-Colman grinder and supported by a bracket bears on the sine bar at a 4-in. radius. Indicator thus shows twice the amount a 4-in.-outside-diameter hob is fed toward the grinding wheel from the dressing position. (Conversion tables are available for use in sharpening hobs of other sizes.)

From dial reading, operator knows how much stock he has removed when his wheel sparks out. (For Barber-Colman grinders of other sizes, operators check stock removal with button micrometer.)

Grinding operator notes amount removed and his check number on Hob Performance Card.

Inspectors check sharpened surfaces and dimensions before tool goes back to control center. Control center measures tooth thickness again with button micrometer and notes it on the Hob Record Card. Hob and its Performance Card go back to production tool crib to start another cycle.

Ford, Too, Controls Perishable Tools

Discussion by **Norman W. Hopwood,** Ford Motor Co.

FORD has adopted a program of tool-change cycles wherein tools are run on a practical, predetermined wear cycle, and are changed at the end of an established cycle in complete sets.

Tools received in the grinding room are examined for signs of abuse, excessive wear, improper handling, and other indications of need for closer control over tool usage. Only in the case of the more expensive tools such as hobs, broaches, and form cutters is the amount of stock removal controlled. We have found that it is not economical to examine all tools in this manner.

After regrinding and reconditioning, tools are inspected for conformance to design specifications and for observance of proper grinding methods.

All divisions of our company have established tool control groups responsible for good design, application, reconditioning, and salvaging of all perishable tools. Our "Manual of Recommended Tool Control Practices" has had company-wide distribution, and a second manual is under way.

The savings that tool control can bring are particularly important with modern transfer-type machines and the automation connecting them. Today, shutting down a machine to change a worn tool may interrupt a large portion or all of the productive capacity of a line of transfer machines. It's advantageous to change as many tools as possible at one time. That is primarily why we have devised our tool-change program.

Production operations leave stresses trapped in finished parts which may add to or detract from operating stresses. More and more, it's being recognized that these residual stresses should be considered in the design of the part and in the planning of its production. So here's a summary for designers and production men of our still-limited knowledge of . . .

How Processing Introduces

Source of Residual Stress	Type of Residual Stress Introduced: Temperature Difference	Phase Trans-formation	Cold Plastic Flow	Warpage	How Manufacturing
Heat-Treatment (quenching and tempering)	yes	yes	no	no	Where the temperature difference between say, the inside and the outside of a part causes stress exceeding the yield point, the metal flows plastically. Residual stress results. If these thermal stresses occurred alone, quenching would put the surface in compression. Transformation stresses develop
Machining	possibly	unknown	yes	yes	Residual stresses follow from the high mechanical stresses associated with the severing of the metal. Their nature depends on the ge-
Grinding	yes	unknown	yes	yes	The combination of stresses imposed by the grain of the wheel rubbing and cutting the metal; the heat generated locally (3000 F temperatures have been reported) and the resulting high temperature gradients; localized plastic flow; and possibly metallurgical phase changes leave residual stresses. Mellon Institute found that in ground fully annealed tool steel,
Cold Working (shot peening, surface rolling, tumbling, honing, lapping, blast cleaning)	no	no	yes	yes	Cold working processes such as shot peening, tumbling, and surface rolling leave compressive stresses in a surface layer. Shot peening a particular ball bearing race introduced compressive stresses as high as 180,000 psi at the surface and 0.010 in.
Straightening	no	no	yes	no	In straightening, some portions of a cross-section suffer plastic flow while other portions are strained elastically. When the bar is bent beyond the yield point, material near the surface yields. Upon removal of the load, the bar returns

R. L. Mattson, Research Laboratories Division, GMC

Based on paper "Effects of Residual Stress on Fatigue Life of Metals" presented at SAE Annual Meeting, Detroit, Jan. 12, 1954. This paper will appear in full in the 1954 SAE Transactions. It is also available from SAE Special Publications Department at 35¢ to members, 60¢ to nonmembers.

Residual Stresses

PRODUCTION DESIGN PARTNERSHIP

Processes Introduce Residual Stresses in Ferrous Parts

when phase changes entail volume changes. Martensite, for example, occupies more space than the austenite from which it comes. Hence, it imposes stresses on neighboring areas as well as within itself. Undoubtedly the transformation itself is affected by the transitional stress state.

The combination of thermal stresses and transformation stresses produces the final stress state. Unfortunately the stress is often tensile at a critical surface. But if we knew enough about these stresses it could just as well be compressive.

Besides quenching and tempering, such processes as case hardening and induction hardening also induce residual stresses via temperature differences and phase transformation. Case hardening alters chemistry, in addition, thereby causing changes similar to temperature-associated phase changes.

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ometry of the cutting tool, speed of cutting, and other factors.

If sufficiently high temperatures are developed locally, thermal stresses or even transformation stresses may occur.

If the metal removed by machining was originally stressed, some unexpected change in shape or size occurs, causing a change in the residual stress in the remainder.

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there is a layer of material stressed in tension in the longitudinal direction. But in the transverse direction, this surface layer is stressed in compression.

More astonishing is that the tensile stress existing at the surface was almost as high as the ultimate strength of the material . . . yet in a layer less than 0.0002 in. beneath, the residual stress was compressive.

Other investigators have found 35,000–50,000 psi residual stresses at the surface of ground low-carbon steel. These stresses extended to depths between 0.004 and 0.012 in.

Grinding with the outside diameter of the wheel produced a surface layer 0.001 in. deep stressed in tension. Grinding with the side of the wheel produced a surface layer 0.015 in. deep stressed in tension. This difference suggests that the larger the contact area between the grinding wheel and the work, the greater will be the volume of material stressed in tension The extent of damage is apparently less for small contact areas, even though actual tensile stresses at the surface are about the same.

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deep. The race was, of course, very hard—over Rockwell C 60.

Compressive stresses of around 100,000 psi and 0.025 in. depth were introduced by shot peening leaf spring specimens of Rockwell C 46 steel. Air hammering with a spherical-nosed tool produced compressive stresses of 40,000 psi and 0.35 in. depth in annealed SAE 1020. Apparently there is a relationship between residual compressive stress introduced and the yield strength of the material.

Because of the residual stresses that cold working leaves, it is a desirable finish operation for parts subjected to fatigue loading.

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to an equilibrium position. Then the surface that was loaded in tension is residually stressed in compression. Also, the surface that was loaded in compression is residually stressed in tension.

Fatigue tests on certain straightened axle shafts showed that the failure always occurred on the side which was residually stressed in tension by bend straightening. Straightening by selective surface hammering or by selective surface rolling to produce residual compressive stresses provides shafts of improved fatigue durability. It introduces favorable compressive stresses in both surfaces.

Designers Pick Up New

JUST as it takes two to tango, so it takes two partners—designer and production man—to create suitable tractor gears. So a gear designer who isn't up on his partner's latest "steps" might just as well be a wallflower. Gear designers who want to keep in step will, therefore, be interested in the results of a recent engineering evaluation of gear-manufacturing processes. Here's what was found when laboratory tests were correlated with field experience:

- Slow-speed gears are stronger, more impact-resistant, and less costly if made of induction-hardened, 500 F temper, SAE 1050 steel rather than carburized and direct-quenched SAE 8620.
- Gears subject to millions of revolutions at relatively high loads are better in many ways when carburized, aircooled, induction-hardened, and rebroached.
- Induction-hardened ring gears last twice as long in service as carburized and direct-quenched ones.

Actually, most engineers in the tractor and farm-implement industry are confronted at some time with the problem of evaluating gears produced by a particular process. However, since the final measure of gear performance is its service life in the field, this determination may take several years.

Therefore, it is important to be able to predict field performance from less time-consuming laboratory tests. The following examples are proof positive that this can be done.

		STATIC TOOTH STRENGTH-LB			COST SAVING PER PIECE USING 1050 STEEL INDUCTION HARDENED		
SIZE O.D.	NO. TEETH	8620 CARB. AND DIRECT QUENCHED	1050 INDUCTION HARDENED	PERCENT INCREASE	MATERIAL	LABOR	TOTAL
$20\frac{1}{4}$	69	58,400	76,700	31	$2.34	$0.07	$2.41
$17\frac{1}{2}$	68	38,500	57,100	48	1.98	0.11	2.09
$14\frac{7}{8}$	72	37,700	47,600	26	1.17	0.30	1.47

Fig. 1—Slow-speed gears are stronger, more impact-resistant, and less costly if induction-hardened, 500 F temper, SAE 1050 steel than if carburized and direct-quenched SAE 8620

Slow-Speed Gears

Take the case of large, slow-speed, final-drive tractor gears. (These gears vary from $14\frac{3}{4}$ to $20\frac{1}{4}$ in. in diameter; have an average of 70 teeth, and a diametral pitch of $3\frac{1}{2}$ to 5.) Such gears rotate at speeds of 10 to 30 rpm and must withstand high beam loads and repeated impact loads.

Several years of field experience have shown that the laboratory beam strength test is sufficient to evaluate this type of gear.

Using laboratory beam strength tests, it has been found that slow-speed gears are better if induction-hardened, 500 F temper, SAE 1050 steel than if carburized and direct-quenched SAE 8620. Besides being stronger and more impact-resistant, the gears cost less when produced this way. (See Fig. 1.)

For a good many years, these gears were made of a carburizing grade of alloy steel and were direct quenched. The demand for additional tractor power, however, placed greater demands on final-drive gears.

Therefore, to increase beam strength and to reduce cost, an induction-hardened gear of SAE 1050 steel was developed. Since the primary requisites of final-drive gears are high beam strength and impact resistance, the induction-hardened gears were tempered at 500 F instead of the usual 360 F for carburized gears.

The 500 F temper gave a slightly softer surface of approximately 54 R_c. This lower surface hardness, it is true, did result in some distress. However, since the total life of a tractor may require less than 5,000,000 cycles on these gears and all these cycles won't be at maximum load, the wear was negligible.

Several years of field experience have indicated that this process is entirely satisfactory.

Speed-Change Gears

Still another example of gear-manufacturing processes being evaluated in the laboratory applies

PRODUCTION DESIGN PARTNERSHIP

Gear-Making "Steps"

W. E. Gustin and D. C. Smiley

John Deere Waterloo Tractor Works, Deere Manufacturing Co.

Based on paper "Engineering Evaluation of Gear Manufacturing Processes" presented at SAE Annual Meeting, Detroit, Jan. 12, 1954.

to speed-change gears used in tractor transmissions. (These gears rotate at speeds of 300 to 1000 rpm and have pitch-line velocities of 350 to 1100 fpm.) Such gears are subject to many millions of revolutions at relatively high loads. Measures of satisfactory performance are wear, pitting, and fatigue-life characteristics. Ease of assembly onto, and stability on, an involute spline are also important.

While laboratory beam strength tests can't be used to evaluate the in-service life of this type of gear, laboratory fatigue tests in a 4-square machine can.

Such tests have shown that carburized, aircooled, induction-hardened, and rebroached gears have the following advantages:

1. Straight spline bore.

2. Better resistance to wear, pitting, and fatigue.

3. The process can be used with a variety of steels: carbon steel to reduce cost; substitute steels in cases of emergency.

Let us consider first what was found when we made laboratory evaluations of differently produced 4¾-in. diameter gears with 26 teeth and diametral pitch of 6.

Three basic materials and processes were evaluated: (1) alloy steel (8620), carburized and direct quenched, (2) medium carbon steel (1050), induction hardened only, and (3) low carbon steel (1022), carburized, aircooled, and induction hardened.

The comparative fatigue strength of three such gears is shown in Fig. 2. (Data for these curves were obtained by conducting laboratory tests in a 4-square type of gear test machine, which runs at

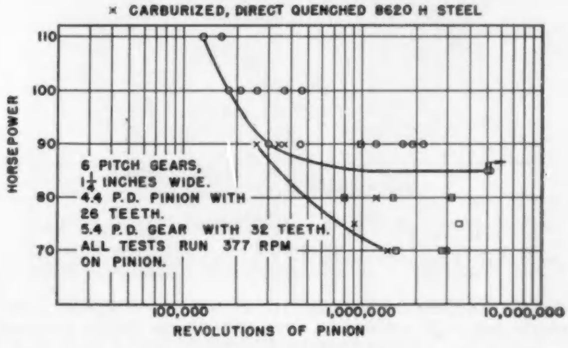


Fig. 2—Speed-change gears of SAE 1022 steel, carburized, aircooled, and induction hardened have better endurance life than carburized and direct-quenched SAE 8620 or induction-hardened SAE 1050 ones

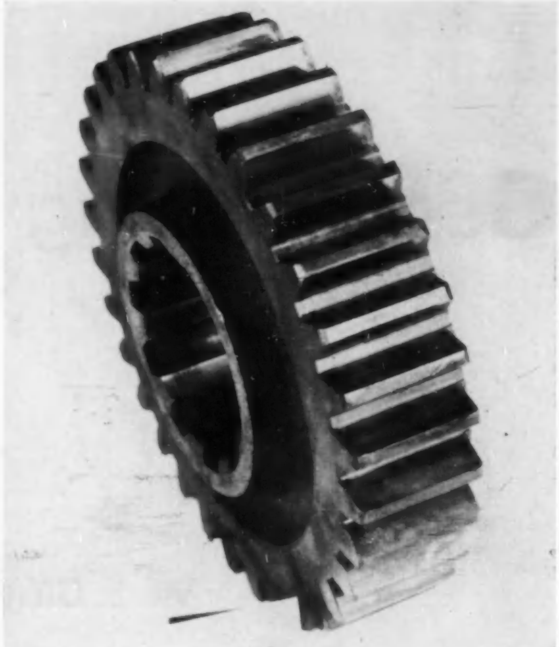


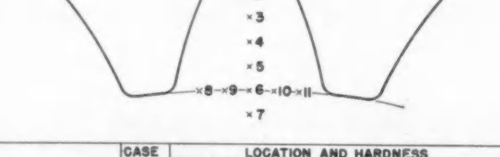
Fig. 3—Medium-sized speed-change gears of induction-hardened SAE 1050 steel pit faster than carburized and induction-hardened SAE 1022 ones. The "1050" gear above (left) was operated three million cycles at a load of 70 hp. The "1022" gear (right) was still in good condition after five million cycles at 85 hp

the same speed as the gears operate in the tractor.)

It can be seen that the gear of SAE 1022 steel, carburized, aircooled, and induction hardened, has the best endurance life. It also has the advantage of a straight bore, which can be obtained on an induction-hardened gear by rebroaching after hardening.

Generally speaking, the gears made of induction-hardened SAE 1050 steel failed by pitting, and breaking out a tooth.

The left-hand side of Fig. 3 shows a typical pitting failure of a "1050" gear. This gear was operated three million cycles at a load of 70 hp. By comparison, the "1022" gear shown at the right was operated for five million cycles at 85 hp load. Note that it is still in good condition.



	CASE DEPTH	LOCATION AND HARDNESS											
		SURFACE	1	2	3	4	5	6	7	8	9	10	11
8620 CARB. AND DIRECT QUENCH	0.040	59	51	44	42	41	37	34	33	37	34	35	37
1022 CARB. AND IND. HARDEN	0.047	61	58	47	38	27	21	17	13	20	17	17	20
1050 IND. HARDEN		59	58	58	58	53	45	33	27	50	35	34	50

Fig. 4—This shows the tooth hardness at 1/16 in. intervals of speed-change-gear teeth produced by three different gear-making processes (Hardnesses are Rockwell "C")

Fig. 4 shows a comparison of the tooth hardnesses of gears produced by the three different methods.

No evaluation of gear-making processes (and materials) is complete, of course, without a cost comparison. This information is given by Fig. 5.

As can be seen, the SAE 1050 steel, induction hardened, is the cheapest process. However, few speed-change gears made this way are satisfactory from the standpoint of wear and pitting.

The major heat-treat equipment for the SAE 8620 steel, when carburized and direct quenched, is the carburizer. The SAE 1022 steel, on the other hand, requires both a carburizer and induction-hardening equipment. Cost of the induction-hardening equipment may be offset, however, by reduced price of the material, by improvement in bore dimensions, and by improved service life of the gears.

Next, let's see what material and process laboratory tests indicated to be best for 3⅝-in. diameter speed-change gears with 19 teeth and diametral pitch of 6.

Two methods were investigated: SAE 8620 steel, carburized and induction hardened, and SAE 1050 steel, induction hardened.

The gears of induction-hardened SAE 1050 were found to have a lower endurance limit. (See Fig. 6.) They also suffered pitting failures sooner . . . and at lower loads. Fig. 7 illustrates this. The "8620" gear (left) is in much better condition after five

	COST PER PIECE		
	FORGING MATERIAL	HEAT TREATMENT	TOTAL COST MATERIAL AND HEAT TREATMENT
8620 CARB. AND DIRECT QUENCHED	$1.123	$0.095	$1.218
1022 CARB. AND INDUCTION HARDENED	.936	*0.182	1.118
1050 INDUCTION HARDENED	.929	0.094	1.023

* INCLUDES REBROACHING OPERATION

Fig. 5—Cheapest way to produce medium size speed-change gears is to use induction-hardened SAE 1050 steel. However, few gears made this way are satisfactory from the standpoint of wear and pitting

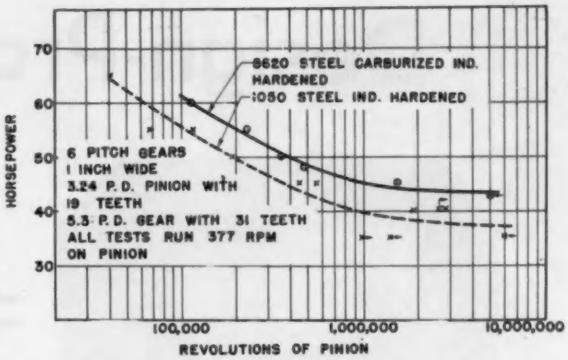


Fig. 6—Small speed-change gears of carburized and induction-hardened SAE 8620 steel have a higher endurance limit than induction-hardened SAE 1050 ones

million cycles at a load of 43 hp than the "1050" gear (right) after only 2½ million cycles at 35 hp.

Ring Gears

An engineering evaluation also revealed a better process for shrinking ring gears on cast-iron spiders. It was found that induction-hardened ring gears last twice as long in service as carburized and direct-quenched ones.

The previous process called for carburizing and direct quenching a ring gear of SAE 8620 steel, then shrinking it onto a cast-iron spider during the tempering operation. The distortion which took place during the quench caused the gear to be out-of-round before assembly. Thus, when the eliptical-shaped gear was installed on the round spider, tensile and compressive stresses were set up at various points. (Strain gages mounted in the fillet over the flat portion of the gear indicated a combined tensile stress of 45,000 psi.)

It was found, however, that induction hardening the gear decreased its out-of-roundness 40%. And this, in turn, reduced the tensile stress from 45,000 to 19,000 psi (a decrease of 55% for the same amount of shrink fit).

Net result was that the service life of this gear, due to the induction hardening process, was improved 100% under full-load conditions.

(Paper on which this abridgment is based is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

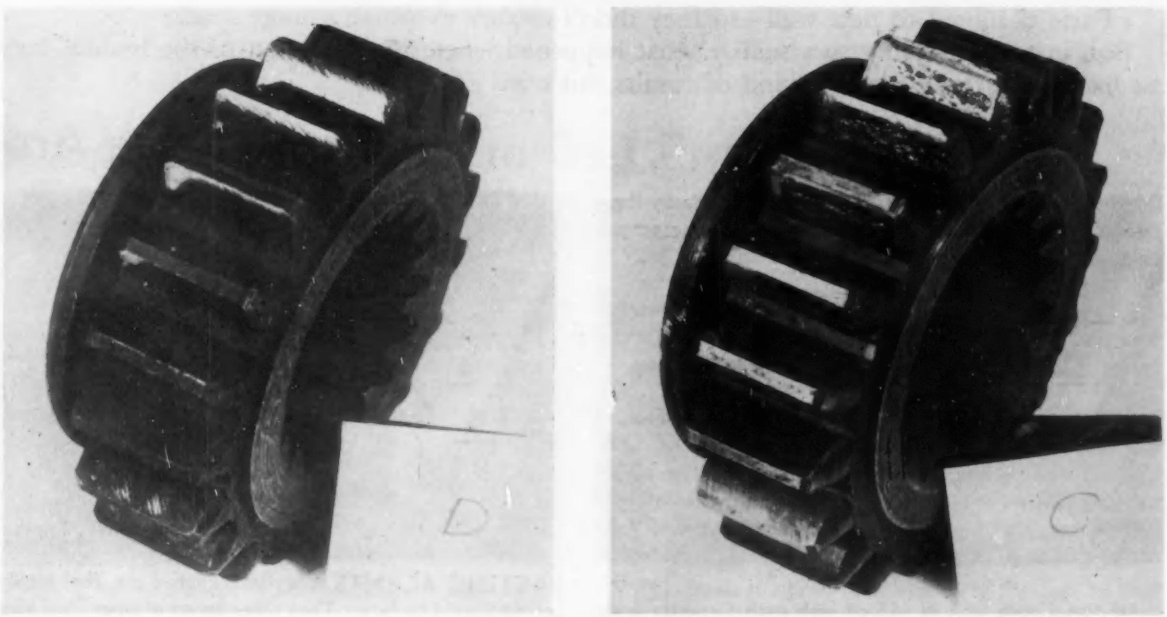
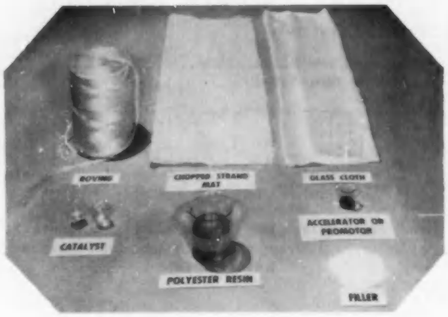


Fig. 7—A carburized and induction-hardened SAE 8620 steel small speed-change gear doesn't pit anywhere near as fast as an induction-hardened SAE 1050 steel one. As shown above, the "8620" gear (left) is in much better condition after five million cycles at 43 hp than the "1050" gear (right) after 2½ million cycles at 35 hp

Design-Production Team



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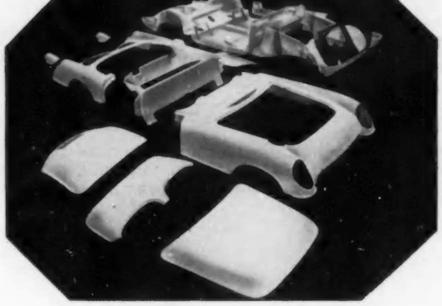


Glass and Plastic

THERE was no one quarterback on the Corvette design-production team. Instead, designers and production men did a lot of blackboard work together before they called such plays as these:

- Hood and luggage compartment openings designed to be entirely within the front and rear upper panels. (This made it easier to maintain size and shape of the openings than if several panels had to be mated.)
- Underbody panel designed so that few reinforcements had to be tacked on during production.
- Parts designed to nest well—so they didn't require excessive storage space.

But, instead of trying to visualize what happened when they came out of the huddle, let's sit back and actually see the kind of results this team got.

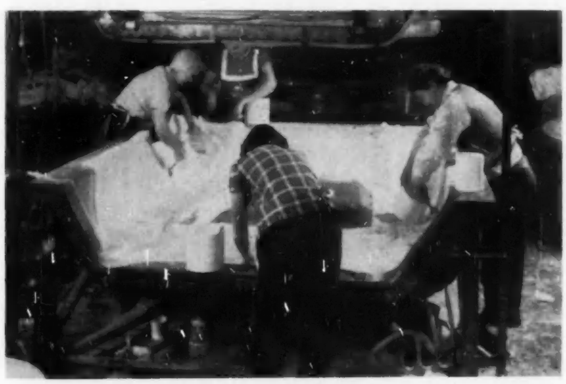
Some Parts Are

RIGHT NOW, Corvette body panels are made by three different methods: hand lay up, vacuum bag process, and matched metal dies.

All parts, however, were designed to meet the requirements of the matched metal die process . . . and eventually, it is expected, all parts will be made this way.

As fast as matched metal die equipment is received, it is put to work in a new 30,000 sq ft supplier plant. This plant is now making some of the parts for the 10,000 Corvettes to be produced in 1954. When completed, it will be capable of producing 10 million pounds of reinforced plastic parts per year.

Of this figure, 340 lb will go into each Corvette body. This will include 136 lb of fiber glass, 153 lb of polyester resin, and 51 lb of inert filler.



PARTING AGENTS are first applied to the highly polished mold surface. Then three layers of fiber glass mat are laid in the mold and a resin mixture spread on with ordinary paint brushes.

Parlays

PRODUCTION DESIGN PARTNERSHIP

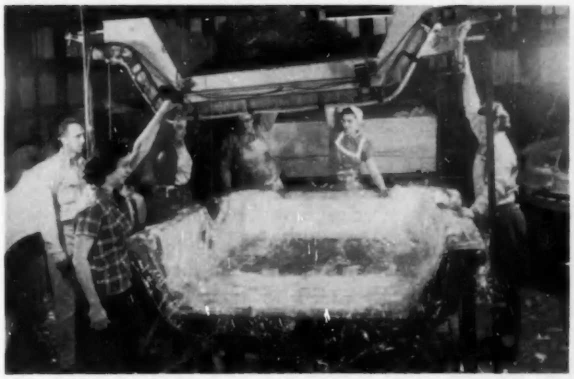
= 

into the Corvette!

E. J. Premo, Chevrolet Motor Division, GMC

Based on paper "The Corvette Plastic Body" presented at SAE Annual Meeting, Detroit, Jan. 11, 1954. Complete paper will be published in 1954 SAE Transactions. Multilithographed copies can be obtained from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.

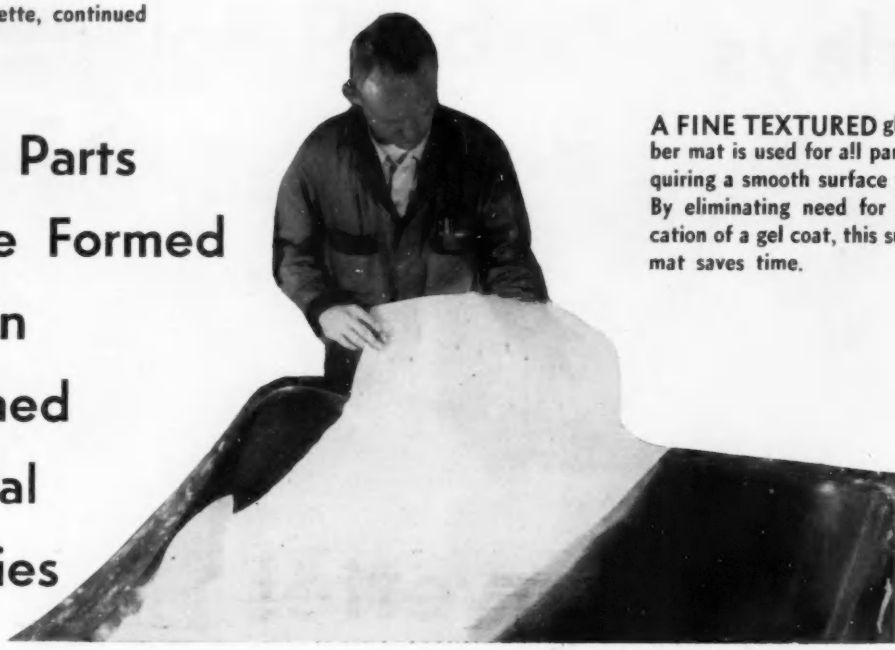
Made by the Vacuum Bag Process



THE "BAG"—a sheet 0.003 in. thick—is next spread over the top of the mold. After the upper part of the mold has sealed the bag around the edges, the air between the bag and mold is pumped out.

12 PSI forms the part, then it is cured for 1 hr by heat lamps in the plywood-box upper half of the mold. Final steps are cutting off flash, sanding surface defects, and washing.

Other Parts Are Formed in Matched Metal Dies

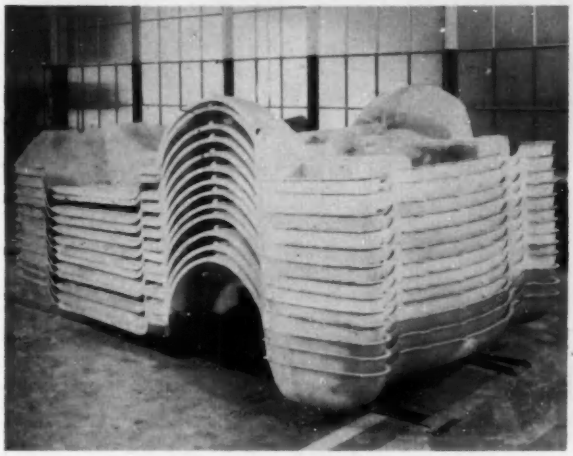


A FINE TEXTURED glass fiber mat is used for all parts requiring a smooth surface finish. By eliminating need for application of a gel coat, this surface mat saves time.

PREFORM is next laid in the die and a measured amount of resin mixture poured on it.

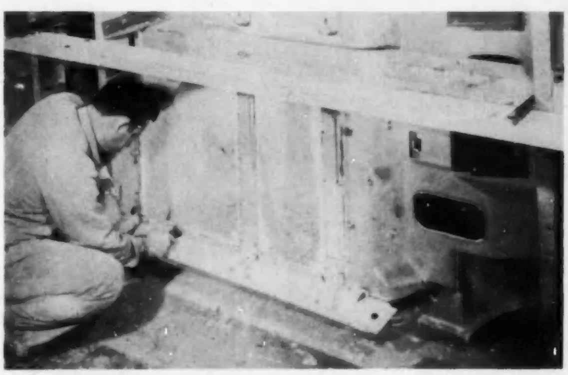
A DECK LID OUTER PANEL is removed after the dies have been closed for approximately 3 min. Edges of this part are then filed or sanded to remove fiber glass not pinched off by the die operation.

But All Parts Meet on the Assembly Line



PARTS NEST WELL and do not require excessive storage space. Some parts, as received, are complete with attaching holes; others require that holes be made. Many parts, such as hoods, side doors, and top stowage compartment covers, are received in a subassembled condition.

ASSEMBLY STARTS with the underbody—the largest one-piece panel used. It is placed in a holding fixture at the beginning of the assembly line and securely clamped. Next, a drill jig is lowered by an electric hoist and the required holes are drilled.



BODY SILLS and floor reinforcements are then bonded and riveted into place. The aluminum rivets used hold the parts together, permitting assembly to proceed without delay. Actually, after the bond is cured they are unnecessary.

ASSEMBLED UNDERBODY is then placed on a body truck which serves both as a conveyer and an assembling jig. This unit holds the body in shape during the assembling sequence. Note the absence of overhead fixtures and cumbersome spot-welding equipment.

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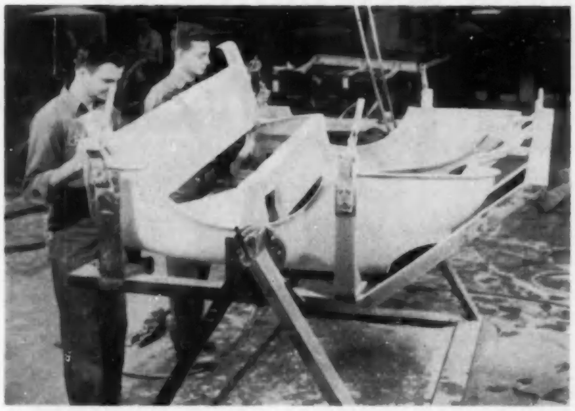
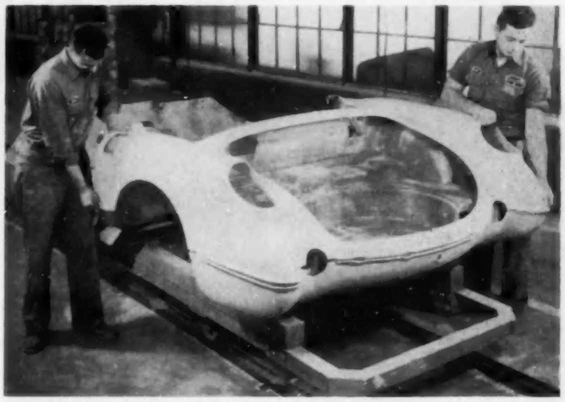


REAR UPPER PANEL ASSEMBLY, consisting of the upper panel, gasoline tank filler box, and the bulkhead, is built on a feeder line. As in the case of the underbody assembly, the joints are bonded and riveted together.



THIS ASSEMBLY is then placed on the underbody, reworking the flanges as necessary to obtain a good fit before bonding. Very little fitting is required. Parts are held together for riveting by spring fasteners.

FRONT UPPER PANEL ASSEMBLY also is built up on a feeder line. It starts with the front fender skirts and the radiator suport. The plastic parts are bonded and riveted together and the metal radiator support is bolted in place. As shown above, this assembly is added to the front upper panel in an inverted position in the next fixture.

It is essential that parts be clamped securely in the correct shape during the assembly operations. Once bonded together, they cannot be twisted into shape the way steel parts can.

COMPLETED FRONT UPPER PANEL ASSEMBLY is then positioned on the main assembling fixture. It is located at the front by the radiator support mounting holes and at the rear by the dash portion of the underbody. No cumbersome door gates or fixtures are required. After the door opening size is checked, the assembly is bonded and riveted to the underbody.

ROCKER SIDE PANELS are next clamped in place. Mated flanges are drilled, bonded, and riveted.

SIDE-DOOR, hood, deck-lid, and top-compartment-cover assemblies are fitted, then removed for painting.

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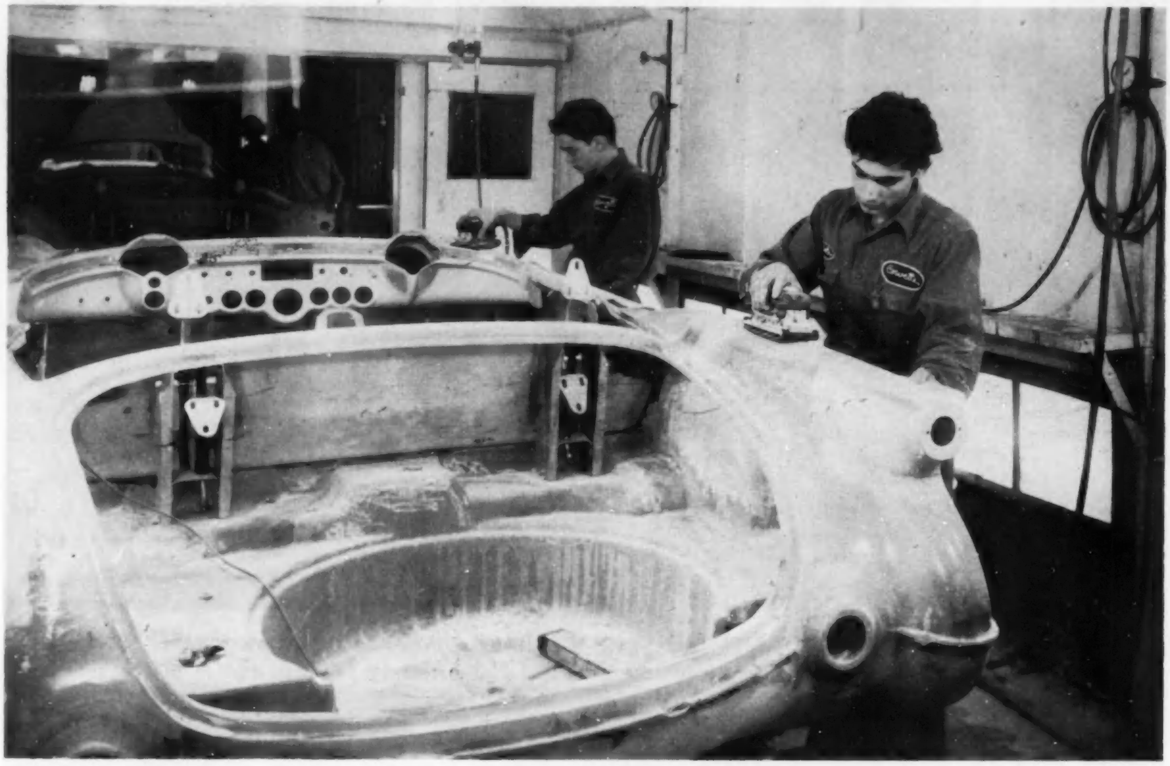
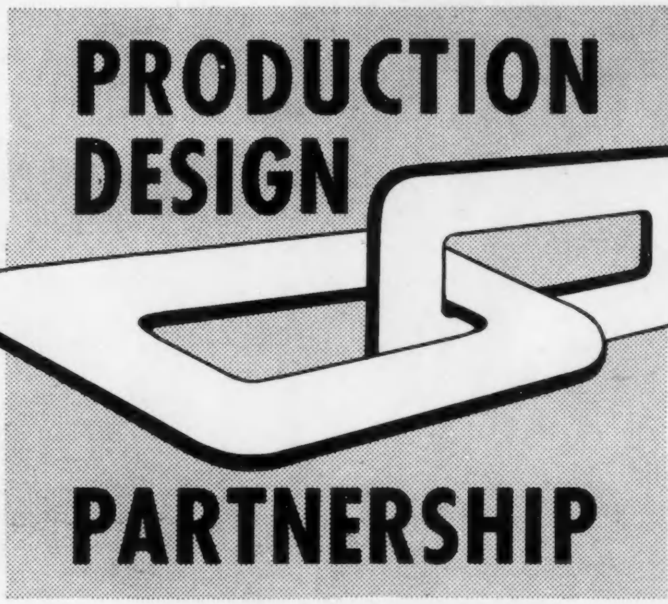


BEFORE PAINTING, all surfaces are cleaned to remove any parting agent that might have been missed when the panels were cleaned at the fabricating plant. Surfaces requiring a high luster paint finish are sanded. The body is then steam-cleaned, wiped with denatured alcohol, and the remaining dust removed with a varnish tack rag. Body glaze is used to cover any imperfections, following which the body is baked and allowed to cool. Excess body glaze is then sanded off. The painting procedure which follows is the same as that used for a steel body.

BODY THEN MOVES down the trim assembly line where it is completed. Here, among other parts, are added the side doors, top stowage compartment cover, and deck lid which had previously been fitted.

DROPPING THE BODY on the chassis and bolting it in place completes assembly of the Corvette. After inspection, performance is checked and necessary adjustments made before the car is delivered to the dealer.

Human Relations Is The Key To The



ADVENT of increasingly more complicated automotive products and machinery for making them is bringing a surprising twist. The relationships of people, production men and design engineers in particular—not functioning of machines—stands out as the big problem in automotive manufacture.

That's what more than 600 production men and design engineers found themselves talking about at the SAE National Production Meeting at The Drake, in Chicago, March 29–31. At Production Forum panels, in technical sessions, and during committee meetings the "Production-Design Partnership" theme was echoed and re-echoed in many variations. And the key word in each case was partnership—partnership of people—to make machines, methods, systems, and processes mesh.

Groups talking about cutting tough jet alloys or automation, coordinating engineering and production or controlling product quality, all focussed on the human relations phase of their specialty. They saw their responsibility as a four-part job to:

1. Clarify the functions of all people in the operation. . . the relationship of each person to the entire operation and to groups and people that make up the whole.
2. Set up communication links to bridge the gap between people and groups in related areas.
3. Give them the tools they need to perform their functions . . . the machines as well as the knowledge.
4. Operate the industrial organism—machines and people—according to a plan, kept flexible to meet changing needs.

Who Does What

Define clearly the responsibilities of people in your organization and their relationships to others and you will lick many of your big headaches.

The Men Who Led the Meeting

R. C. Archer (left), general chairman of the meeting, and A. W. Phelps, sponsor of the meeting who was also toastmaster at the dinner

That's what one executive at the meeting said and he drew nods of approval from several hundred at a technical session. False starts, dropped balls, and aimless efforts practically evaporate if your people truly know their areas of responsibility.

E. N. Cole, chief engineer of Chevrolet, and E. H. Kelley, Chevrolet's general manufacturing manager showed how and why it's done in their organization.

Cole showed a clear-cut understanding of his functions in Chevrolet . . . creation of a product program that reflects the knowledge and foresight of sales, manufacturing, and financial management, with special emphasis on manufacturing coordination. Said Cole: "Every manufacturing operation that is 'design-sensitive' costs money; every unnecessarily close limit causes scrap." He noted that in Chevrolet, a penny saved is $17,000 earned.

Kelley backed up this thinking by saying that each of the two groups (production and engineering) has its own field of operation, but neither can function as a separate unit. For example, costs would go way out of line if the master mechanic didn't work with engineering on modifying a new design to permit use of existing manufacturing facilities.

At the Quality Control Panel, discussers showed

how clarification of function has upped product quality. It used to be that inspection was held responsibile for quality. Eventually management began to recognize that inspection could only separate the bad parts from the good. And even with 100% inspection, some 10% of the bad parts would get through to the customer.

It became clear that the production department, which fabricates the part, controls its quality. And how well it's done depends upon the realistic tolerances and specifications demanded by engineering . . . again the production-design relationship.

Joe Adams, of White Motor Co., defined an even more subtle responsibility of management . . . the working relationship between supervisors and subordinates. According to Adams, "Management must recognize that people cannot be expected to adapt their personalities to fit the boss. The success of the executive will be determined by his ability to handle men reporting to him by adjusting his own approach to the man in question. It permits his key assistants to work at their greatest efficiency in a relaxed atmosphere. This is a contagious attitude which soon works its way down through all levels.

"Each man should be encouraged to develop his own strength and initiative as part of the team, rather than forced into a mold."

Channels for Interchange

Well-established functional centers aren't enough to make the industrial organization tick. Men from all branches of production and engineering at the meeting agreed that communication pipelines have to be established and kept open between the various units, if the industrial organism is to survive and prosper.

In Chevrolet, the link between manufacturing and engineering is the production engineer. He's the one who works out with the master mechanic the best manufacturing methods; with chemical and metallurgical departments—development of processes for new design specs; with purchasing—testing of vendor materials and parts; with traffic—design to minimize transportation costs.

Kelley and Cole pictured the production engineer as a man with many skills (both technical and human relations). Often he's a design engineer who found he liked to get cutting oil and cast-iron dust on his hands. He can talk the language of the machine operator and the design engineer specialist . . . and gets along with both.

Kelley told how he once won over several old school die makers when he was a production engineer. They had dug out crankshaft dies for many years and were wizards at their trade. But Kelley just couldn't reach them, win them over to his ideas.

One day, one die maker spoiled Kelley's new shoe shine with a wad of chewing tobacco juice. Next week, Kelley returned and let this same shop man have an even bigger wad down his pants leg. From then on, Kelley and the boys in the shop were pals.

Norman Shidle, editor of the SAE Journal, observed that while big organizations (like Chevrolet) need the liaison function, small outfits could do a better job if they had it in every-day, normal operations. The large company would have people falling all over themselves without it. Unfortunately,

Around the Meeting . . .

The late **Dwight Morrow**, according to Chevrolet's **Ed Kelley**, once wrote to his son:

"The world is divided into people who do things and people who get the credit. Try if you can to belong to the first class. There is far less competition."

The March 28th blizzard which greeted the meeting at its opening had few ill effects. Nearly 500 production men swapped information at the opening day's Forums—more than at the same meeting last year. . . And the airports had opened up again by the second day and brought all the important guests and speakers in on schedule . . . Total attendance for the entire meeting was over 600.

The design engineer's aim, according to Chevrolet's **Ed Cole**, should be to "design it so they can't build it wrong."

"There's no way you can get a production engineer out of college. He has to be trained in industry—on industry jobs," said Chevrolet's **Ed Kelly**.

GENERAL CHAIRMAN R. C. ARCHER, formally opening the meeting, said that our high standard of living stems from engineering products for better production. Still more efficient production will come from a closer relationship between design and production engineers.

MORE THAN 200 men boarded buses and used their own cars in visiting the Hotpoint Co. plant and the Melrose Parks Works of International Harvester Co. on the last day of the meeting.

DEFINITION OF A MIXED BLESSING—Your mother-in-law driving your new car over a cliff.

At the Dinner . . .

(Left to right) Merrill R. Bennett, chairman of the SAE Chicago Section, SAE President William Littlewood, and dinner speaker Kenneth McFarland

A. W. PHELPS, Chairman of the Board, Oliver Co., who was sponsor for this most-successful-to-date SAE Production Meeting, was toastmaster at the dinner which climaxed the event on March 30. He was introduced by SAE Chicago Section Chairman Merrill R. Bennett, who opened the dinner proceedings. "SAE is doing much," Bennett said, "to foster design-production relationships."

SAE President William Littlewood, vice-president, American Airlines, in a brief talk, emphasized the importance of design production relationships throughout every phase of the automotive industry. He also pointed to the growing need for attention to service and maintenance of products, of whatever kind, and bespoke increased engineering attention to these areas.

McFarland Gives Leadership Challenge

"The time has come for leadership which can organize and capitalize on the deep spiritual yearnings that are stirring all over the world." With this sentence, Dr. Kenneth McFarland, General Motors' Educational Consultant, introduced that part of his address which struck home to the hearts of many of his listeners. McFarland was the principal speaker at the dinner.

"Everywhere", he said, "people are reaching upward as they grope for a better way than the tension, turmoil, and torture which torment our times."

"Thinking tall", he called this upward surge of man's thought. As one gets to "thinking tall," his remarks indicated, one is likely to find himself being tall.

People in all walks of life, McFarland said, responded to the greater understanding of spiritual as well as material needs our country has seen recently. "People who are joined together in a prayer," he concluded, "will be difficult to separate on any other basis."

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the small organization, can function without the liaison function, however haphazardly, but would operate more smoothly, more efficiently with it.

In Wright Aeronautical, the liaison function comes under the manufacturing engineering manager, said R. J. Moran, the man who holds down that job, and Michael Field, of Metcut Research Associates. Wright's manufacturing engineering department translates a new design, from blueprint stage right through to where production can start turning out parts in quantity. It takes on the big job of creating new processes, tools, and machines for fabricating nonconventional jet engine parts.

Channels for idea exchange are musts between people of different companies as between those within one company. Here vendor-buyer relationships came in for attention.

Production men griped about machine tool designers being unaware of metal-cutting needs. For

example, carbides are now being used just about to the limit of tools designed for their use, it was said at the Production Tooling panel. Unless metal-cutting plants get more rigidity in work hold devices, carbide progress will be arrested.

On quality control, closer liaison is clearing the air between vendors and users. Consumers have come to see that the difference in price between perfection and 1% or 2% defective can be prohibitive. Vendors are giving their customers certified quality control charts, which specify the quality range guaranteed to be delivered.

Tools, Tangible and Intangible

Manufacturing men and engineers agreed that phase three of their human relations task, really an integral part of the function definition and communication sides, is to properly equip their people. And equipment here means physical tools as well as the needed knowledge.

Ways of imparting the needed knowledge came in for discussion at the Selection and Training panel. Most agreed that the best technique is for those in the line organization to get together with specialists in training methods.

Some plants have found psychologists useful in training supervision. They can be effective in explaining behavior motivations. But don't let your psychologist go psychiatric and actually diagnose cases, several men warned. It can be harmful.

One engineer said his company made a study of executive development. It started by boiling down to common denominators the qualities of its top executives and found that in almost each case, the man had:

1. Some training, experience, or aptitude in public speaking.
2. Some prior business experience in other organizations.
3. Some one person who at one point in the executive's career gave the executive direction in objectives and guidance in human relationships.

Several men felt that the training and educational job should be a continuous one, not to be stopped at the end of the formal training program. And this information-passing, should move two ways, they said, up to top executives as well as down to subordinates.

From the Manufacturing Expense Control panel came the advice to feed top management short reports. Get all the significant facts and figures on one page, one man said. Main aim should be to get only significance to management. But be ready to feed your boss the details if he indicates an interest in them.

Quality control engineers emphasized the need for proper tools and controls in the production-design area. Engineers were so bent on top performance of their product that they specified unrealistically close tolerances. Came the tool of statistical quality control and the shop was at least able to prove the natural tolerances of a process. With these facts on hand, production men are now able to work out harmoniously with design engineers tolerances feasible both economically and technically.

Automation is another big area where informa-

Around the Meeting . . .

EMIL GIBIAN and **CARL HECKER** chairmanned the two technical sessions. Both kept the session secretaries busy (**ROBERT WARD** and **THOR STROMSTED**, respectively) by stimulating lively discussion from the floor.

DEFINITIONS: Repartee, says **Dr. Michael Field**, is the retort you think of the morning after. An optimist, according to **Kenneth McFarland**, is a lady church-goer who starts putting on her shoes when the preacher says, "And now in conclusion. . ."

Those at the Expense Control and Manpower Scheduling Forum seemed to agree on this: When permanent personnel reduction becomes necessary, it's probably better to do the whole job quickly and at once, than to drag it out. . . The faster everybody knows the cuts are over, the better it is for the morale of those remaining.

"Anything that can be measured can be reduced to numbers. And anything that can be reduced to numbers can be analyzed statistically," quoted someone at the Quality Control Forum.

Principal Dinner Speaker **Kenneth McFarland** read the following poem, written to him by his boyhood schoolteacher a few years ago:

"It takes big men to deal with small towns
And not themselves grow smaller year by year
To stand the endless flick of envious tongues
And not mind too much—but to see the reason clear.
The aching need the people have for power or love
The bitter emptiness of those who fear
The passing decades, slipping week by week,
The gentle, awful patience of the meek
Who feel within themselves some great lack
Of vigor to attack, or even to hit back—
So they resent the ones who do excel.

But if one truly knows his town he'll find
Its people no more cruel than they are kind
He'll see the shining goodness—all the care
They give the sick or needy neighbor there.
He'll see the washerwoman's youngest son
Playing with the banker's boy, they're one,
But he who does not truly know will see
Only the smallness and the snobbery,
And slowly with the years he will become
One thing he sees—its essence and its sum."

The Men Who Led the Production Forum

E. O. Wirth (standing) was co-chairman of the Production Forum. He is giving last-minute advice to some of the panel leaders, who are, left to right: Byron Stewart, Delco-Remy Division, GMC, Selection and Training of Technical and Supervisory Personnel; J. F. Jones, Hudson Motor Car Co., Production Tooling and Shop Methods; L. C. Daniels, Buda Co., Materials Handling, Plant Layout, and Material Flow; and B. F. Armbruster, Oliver Corp., Manufacturing Expense Control and Manpower Scheduling

C. L. Hecker (left), co-chairman of the Production Forum, relaxes with the other four panel leaders just before the Forum started. The leaders are, left to right: W. R. Slattery, Ford Motor, Automation—Manufacturing Research; F. J. Halton, Deere & Co., Inspection and Quality Control; Robert Wise, Booz, Allen and Hamilton, Production and Material Control; and W. J. Collier, Thompson Products, Preventive Maintenance of Plant Equipment

tion has to be continuous, where the design-production relationships are vital. Kelley said Chevrolet is now studying intensively just how far it can go with automation. The heavy investment in an automated production line indicates a need for new thinking in product design. At the same time, Cole and Kelley agreed, some new thinking is in order on automation so as not to impede design progress. Automation with built-in flexibility is the goal.

An indication of a new trend in automation is new high-speed assembly machines built by Delco-Remy, said C. A. Nichols and W. A. Fletcher, of that organization. They showed how the automation concept, normally associated with large parts like cylinder blocks, has been tailored to assembly of small components. These machines are less than 15 ft long, and cost about $20,000. They perform a combination of operations such as machining, joining, packaging, automatic feeding, inspection, and cleaning. They maintain production rates up to 1600 per hr on automotive electrical equipment units.

Blueprint for Operations

Implicit throughout discussions at the meeting was the need for a plan or program aimed to achieve the organization's objectives. Without it, the clarification of functions, communication pipe-

SAE Production Veep Performs on Video

SAE PRODUCTION ACTIVITY COMMITTEE took time out from its luncheon meeting on Wednesday to view television and see . . . E. D. KEMBLE, (right) SAE vice-president for the Activity, being interviewed on the significance of automation on Chicago's "Betty and Bob" program

lines, and machine and information tools become floating ships without rudders.

A program from which all other phases of the production-design job can be projected is a must for small as well as large organizations, men at the meeting argued. And to be successful, it has to be a product of the minds of men who will participate in its execution.

As Cole noted, Chevrolet's car design is a product of engineering with recommendations from sales, manufacturing, and finance executives. For a specialized product manufacturer like White Motor, said Adams, it's essential that the people involved have some say about the detailed planning and programming.

He underlined flexibility in planning systems for the diversified producer. (Large volume producers regarded flexibility as an equally essential ingredient in their planning.) Said Adams, "As the special nature of the planning function increases, the concept of 'system' changes from one which rigidly outlines each step in the conversion of the customer's order to the finished product to one which encourages the exercise of discretion by the *people* involved in the system."

Paul A. Miller (left), vice-chairman for meetings of the SAE Production Activity Committee, and E. D. Kemble, SAE Vice-President for production

Forming Titanium . . .

. . . for DC-7 nacelle a success with normal stretch press practice. Above average quality parts obtained using similar tools, same equipment and personnel, employed for stainless steel fabrication.

Based on paper by **J. R. Franks and C. S. Glasgow** Douglas Aircraft Co.

IN building the all-titanium nacelle on the DC-7 only pure titanium was used and then only for such parts as could be made by power brake forming, Hufford stretch press forming, and Erco and Sheridan stretch press forming, such as Zee sections and skin plating.

We started with the requirement for power brake forming at a temperature of above 600 F, although previous experience indicated stretching could be done cold. However, cross-section inconsistency made apparent that hot brake forming was not going to produce acceptable parts where subsequent stretching and joggling operations were involved.

Since one titanium Zee section was identical to a DC-6 Zee section, an attempt was made to "size" a power broken titanium Zee by running it through the last pass of the Yoder Roll available for the DC-6 part. This experiment showed it would be possible to cold Yoder Roll titanium due to the fact that the heel line of the part was moved as much as ¼ in. without cracking when "sized."

Stretch forming of titanium skins proved extremely successful. Parts were formed on both Sheridan and Erco stretch presses using both normal and parabolic dies. Hufford stretch forming was done with a minimum amount of trouble. Parts were stretched over standard Hi-Den blocks with no springback allowance. Most of the Zee's had varying bevel flanges ranging from 2 deg closed to 4 deg open and the parts formed in well on the stretch operation with little hand work. Handwork was reduced if flanges were formed 2 deg closed before stretching. All joggling and dimpling operations were performed with material heated to a temperature above 600 F.

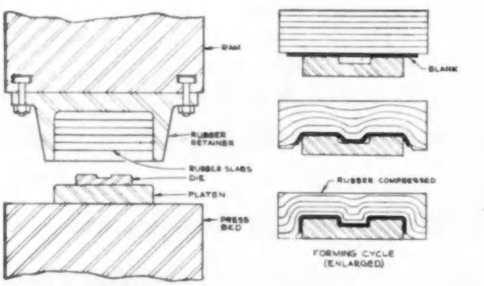
There was no need to deviate from accepted practices with Erco, Sheridan, or Hufford stretch forming. The same equipment, similar tools, the same personnel were used as for stainless sheet steel fabrication. Damaged, broken and unacceptable parts were lower. Quality was above average. Blanking and shearing operations were done under conventional procedure for stainless sheet. The pierce blank template operated as well with titanium as with stainless.

Hot brake forming, dimpling and joggling followed accepted procedures and the parts requiring these operations were free from cracks and failures. Problems were met in operational routine but nothing attributable to the properties of titanium as being radically different from other types of steel. (Paper "Tooling and Planning Problems Related to Modern Transport Aircraft" was presented at SAE Annual Meeting, Detroit, Jan. 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

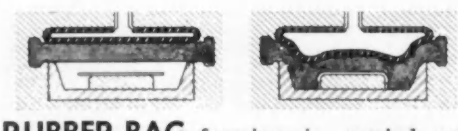
Forming Proves Able Grappler

Rubber Forming Takes Strong Alloys in Stride

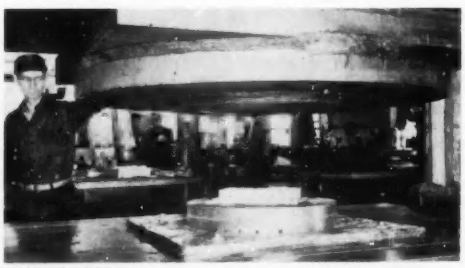
3 Rubber-Forming Techniques



HYDROPRESS rubber forming is usually done with a single-action open-type hydraulic press. A rubber pad, mounted on the moving platen, replaces the conventional female die. (This not only reduces initial tooling cost, but also cuts male die wear.) As the slide descends, the rubber flows around the die block, forcing the metal blank to take the exact contour of the die.



RUBBER-BAG forming is carried out with direct hydraulic pressure. Oil from a high-pressure pump is forced into a rubber bag or diaphragm enchambered behind a rubber pad. Resulting expansion of the bag causes the pad to flow around the contour of the male die, thus forming the piece.



IMPACT rubber forming is a newcomer. Here, a drop hammer is equipped with a trapped rubber head. Principle of forming is similar to that of hydropress rubber forming. Dimensions of the forming area, however, are considerably less. This increases forming pressure and permits forming of heavier gage metal. Parts are formed faster, too, than with the slow-acting hydropress.

VALUE of the rubber-forming process to the aircraft industry has been enhanced in recent years by use of higher pressures. Up until World War II, the average pressure used was in the range of 1100 psi (a forming pressure which did a fair job on lower strength materials). With the introduction of such high-strength materials as 75S aluminum, 1100 psi no longer proved sufficient to properly form them.

Two alternatives faced the aircraft industry: To revert to costly mechanical dies or to confine the rubber pad to smaller areas so as to secure higher forming pressures. Several companies took the latter step, designing containers for higher pressures and, in some cases, procuring higher capacity presses to permit the higher pressures to be obtained over larger areas.

As a result, forming pressures today range as high as 2500 to 5500 psi, with a few from 7000 to 10,000 psi. Actually, however, such new materials as 78S

In Aircraft Arena

PRODUCTION DESIGN PARTNERSHIP

R. E. Furgeson, North American Aviation, Inc.

Based on secretary's report of Panel on Forming held as part of the SAE Aircraft Production Forum, Los Angeles, Sept. 29, 1953.

aluminum, titanium, high-strength steels, and magnesium may require use of even greater pressures. With this in mind, experiments are now being made with pressures of 20,000 to 40,000 psi.

One aircraft company is currently using a 7000-ton press. This unit can exert a forming pressure of 2430 psi on a 48 × 120-in. pad or 3600 psi on a 40 × 100-in. one. Other companies are using various capacity presses with container sizes ranging from 18 in. in diameter to over 48 × 120-in. rectangular shapes.

The high-pressure rubber containers for these rubber-forming presses can be made a number of ways. Both forgings and laminated-plate construction are satisfactory if structural requirements of the container are met and if proper fabrication procedures are used.

Containers should not be cast! Why? Because of the difficulty of obtaining a sound casting completely free from defects. In short, a cast container is too likely to fail suddenly, spewing shrapnel in all directions.

As for the design of containers, one company has found that round ones are best for high-pressure (5500 to 10,000 psi) applications. Round containers do, however, have certain size limitations.

Inspection is in order to make sure that rubber containers are safe. One concern uses a reflectoscope to ultrasonic test all high-pressure containers on arrival. Then it visually inspects each pad holder every 60 days.

Just as higher pressures have made possible advances along the rubber-forming front, so has the new rubber-forming technique—impact forming (see box). This fast-action forming method has permitted giant strides to be made in the hot-forming area. Thanks to the shorter time the rubber pad is exposed to high temperatures, pad life is increased several hundred per cent. There is also less temperature loss because of the faster hot-forming cycle. Last but far from least, the high pressures that can be obtained result in cheaper and higher quality parts.

Titanium Presents Stretch-Forming Problems

STRETCH-FORMING techniques have been perfected to the point where no specific problems are being encountered with most aircraft materials. Titanium, however, is proving a real headache. Both the pure metal and alloys of it are difficult to stretch form because inconsistencies in these materials lead to nicking. This makes perfect edges, suitable heating, and slow forming speeds prime requirements.

Springback, too, is a problem with stretch-formed titanium pieces. Techniques have not yet been developed that can control it mechanically. Springback can be worked into the form dies, but it still may vary from part to part. Currently springback of titanium parts is being corrected by bench operations using heat and secondary hand-working devices.

It is important to inspect titanium to make certain that the shop is receiving quality material. One producer pulls out as samples four sheets of each gage of each heat that is shipped. The mill tests two of these four sheets and sends the other two along with the test results to the customer. If the customer disagrees with the test results, 100% inspection is made of the controversial shipment.

Two companies segregate the material into classifications, depending on its quality and formability. The best sheets are then issued for fabrication of complex parts, and the marginal stock is issued for shallow contour and flat applications.

Continued on next page

Hybrid Draw-Forming Cuts Fabricating Costs

WHILE conventional double-action draw forming is used to some advantage in the aircraft industry, in general, excessive tooling costs hold down its use. Ordinarily, other methods of draw forming are employed. Wide use is made of drop hammers and, in some cases, a combination of drop hammers and stretch presses.

Tooling costs have been greatly reduced by these methods. Take the case of a duct leading edge that was formerly two pieces welded together. (See Fig. 1.) By preforming on a stretch press and finish-forming with a drop hammer, this part can now be made in one piece. Result: A higher quality part that costs less to make.

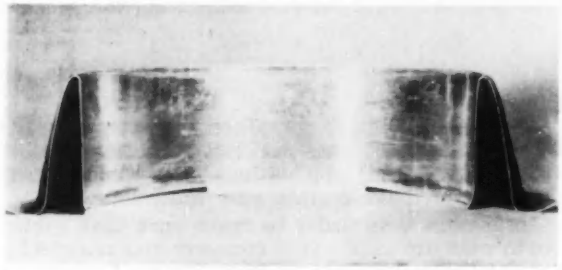


Fig. 1—This duct leading edge, formerly two pieces welded together, is now made in one piece by preforming on a stretch press and finish-forming with a drop hammer.

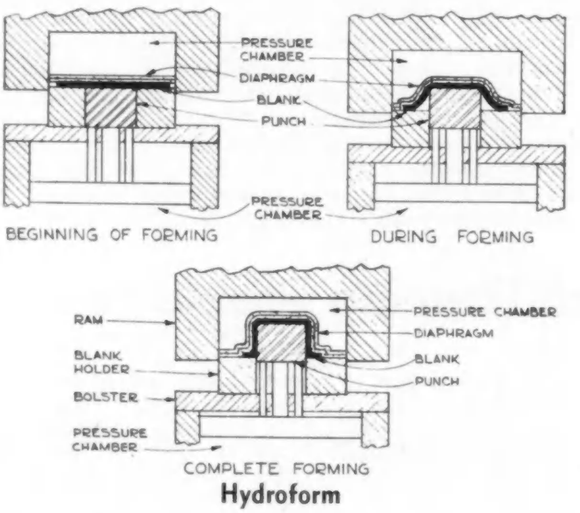
Parts having recessed and embossed areas generally are formed today on drop hammers. Mostly this can be attributed to the low cost of the tooling and the shorter time required in developing a tool for the initial run.

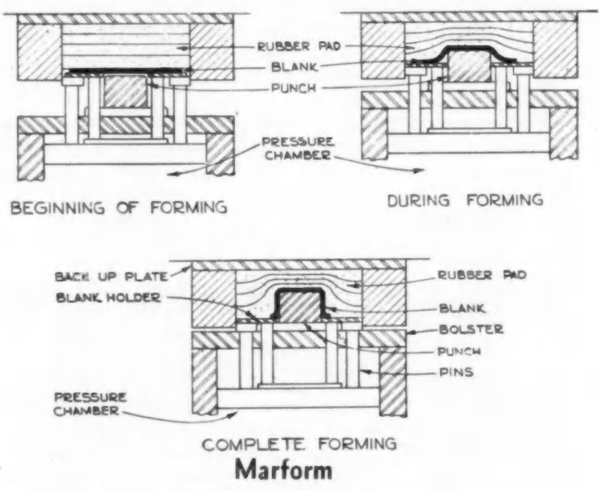
Other currently used methods of aircraft draw forming are Hydroform, Marform, and Hi-Draw. (See Fig. 2.) The economic advantages of these processes become readily apparent when consideration is given to the additional tooling, material, and labor required with mated punch and die assemblies.

One aircraft company has found that the Hydroform process results in some cost reduction in the production of symmetrical parts . . . and substantial savings when used to make non-symmetrical shapes.

Parts with narrow flanges and recesses are being economically produced by Hydroforming. This process is particularly good for drawing parts with sharp corners and flange radii that would otherwise (1) require frequent re-cast of lead punches used in drop hammers and (2) involve the added cost of a mated kirksite punch.

Thinning out of material in strained areas of components for sealed containers is sometimes sufficient cause for rejecting them. For such applications, the ability of the Hydroform machine to produce parts with little or no variation becomes a factor of utmost importance.





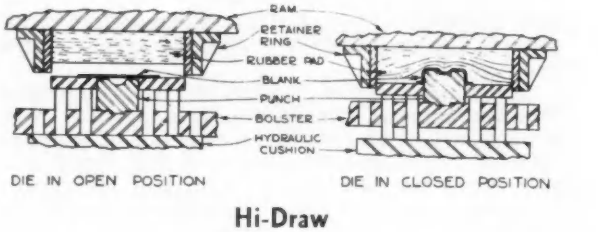


Fig. 2—Three currently used methods for draw forming aircraft parts are the Hydroform process, the Marform process, and the Hi-Draw process

Integrally Stiffened Parts Formed Seven Ways!

SCULPTURED and integrally stiffened parts pose one of the biggest forming problems faced by the aircraft industry today. They are being formed, with varying degrees of success, seven ways:

1. Rolls and brake forming
2. Constant-moment bending
3. Shot peening
4. Stretch forming
5. Die-quench forming
6. Metallic-shot die quenching
7. Hydrodynamic die quenching

Roll and brake forming—Attempts have been made to form integrally stiffened skins by using forming rolls, power brakes, and mated dies. In most cases, results have been unsatisfactory due to (1) premature material failure, (2) dimensional changes caused by temperature variations releasing localized strain points, and (3) inability of the equipment to form parts with variable thickness.

Forming of integrally stiffened skins is further complicated by changes in cross section and warpage in the part brought about by stress relief in the machining operation. It's true that forming may be done with the material in the soft temper. But the subsequent heat-treatment and water quench required to develop full structural strength of the material invariably cause the part to undergo stress warpage. Such deviations are virtually impossible to correct.

Constant-moment bending—This method is used by one company to form the contour in a 75S-T6 integrally stiffened wing panel. Constant-moment bending, wherein forming is performed on heated material in the full hard condition, reduces residual stresses to a minimum. It calls for use of a 2-contact-point punch instead of the conventional single-point one. (See Fig. 3.) Bending stresses, therefore, are uniform between these points. Thus the forming takes place over a larger area, thereby reducing strain.

Shot peening—Shot peening is customarily thought of as a means of improving fatigue life characteristics of metal parts. But recently it has been adapted to the forming of integrally stiffened skins. Shot peening, in this case, stretches the peened surface to the desired contour.

Since the material forms in the direction peened, there is no way in which a die may be employed. The solution lies in peening intensity or air pressure, shot size, and the time of exposure. Greater pressures are required on thick sections and vice versa.

This forming technique requires a highly flexible control over shot intensity and a skilled operator. With the experience gained on successive runs, an operator is often able to form satisfactory parts in one operation on each side of a panel.

Not only does this shot-peening process form parts satisfactorily, but it also leaves a compressive layer on their surfaces which protects them against stress corrosion.

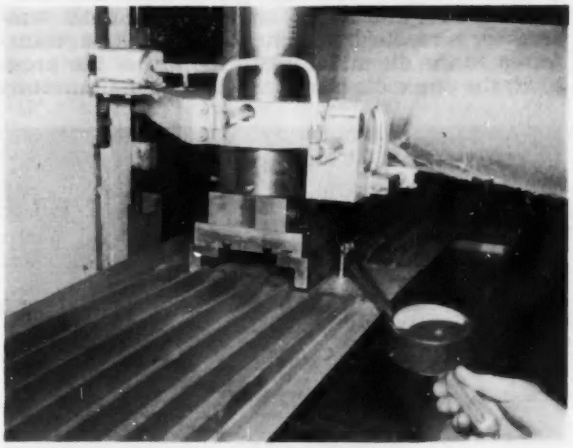


Fig. 3—Constant-moment bending is done with a 2-contact-point punch instead of the conventional single-point one. Since bending stresses are uniform between these points and forming takes place over a larger area, residual stresses are reduced to a minimum

Stretch forming—Fig. 4 illustrates a successful method of stretch forming a sculptured fuselage skin. (Material: 1/8 in.-thick 75S-T6 alloy aluminum, sculptured to 0.096 and 0.072 in. in certain areas.) The part is first heat-treated and start-formed in the Q-condition on a 20-ft power roll. The finish-forming operation (shown below) is accomplished on a stretch wrap forming machine. A clamping device holds the sculptured areas snug up against the die during the stretch cycle. This allows the part to pick up friction from the die, eliminating nicking and buckling in thin areas.

The clamping device consists of straps over a sheet-metal cover which hooks into the backing plate of the machine. Adjustable screws in each

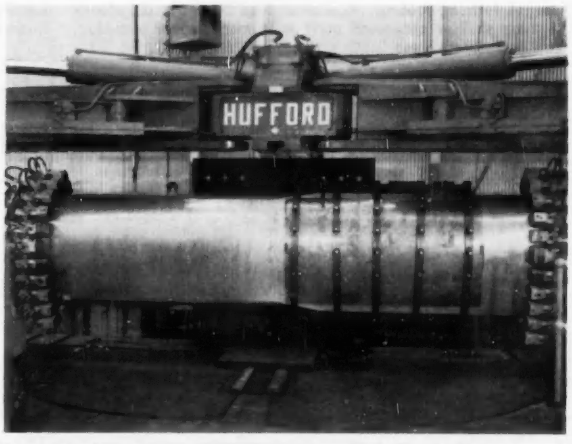


Fig. 4—Sculptured fuselage skins are being successfully finish-formed on stretch wrap forming machines

strap allow the sheet-metal plate to be adjusted tightly against the skin. The plate has a ⅛ in. rubber pad glued inside to prevent its scratching the skin.

Die-quench forming—First step in the form-die quench cycle is to place the metal blank in a heat-treat furnace and hold it there until uniform temperature is reached. The heated part is then transferred to the die anchored to the bed of the press. Next, the upper die is brought down, simultaneously

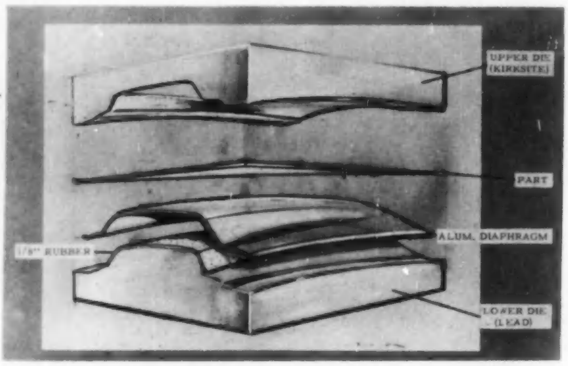


Fig. 5—With the die-quench forming process, an aluminum diaphragm acts as a quenching medium and assures complete die contact

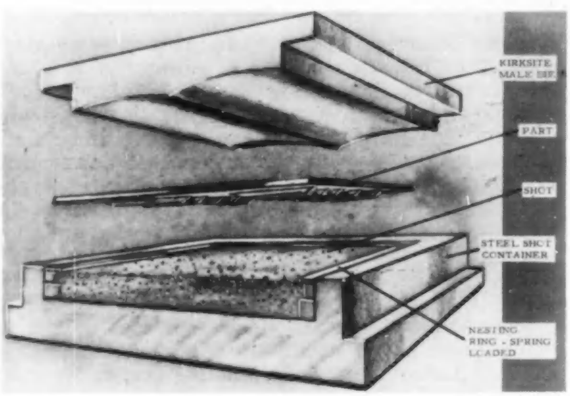


Fig. 6—This shows the die arrangement for the metallic-shot die-quench forming process. Use of shot as the lower die member permits forming shallow contoured parts with machined or extruded stiffeners and sculptured areas

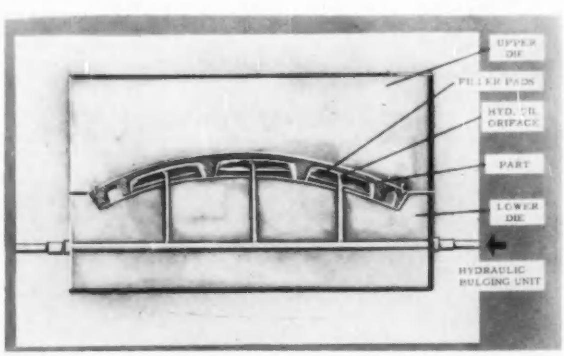


Fig. 7—With a new forming process—hydrodynamic die quenching—high-pressure fluid forms the part while it is securely held in the die under ram pressure

forming and cooling the part by metallic conduction through the relatively cold die surfaces. An aluminum diaphragm, placed on a ⅛ in. rubber pad, acts as a quenching medium and assures complete die contact—an essential with this process. (See Fig. 5.)

At the heat-treat temperature, the metal stretches uniformly in all directions in fine increments. (Thus, springback and residual stresses are entirely eliminated. This, in turn, puts an end to costly hand-straightening work.) A permanent stretch or deformation of the metal is achieved by subjecting the expanded metal to the constantly applied high forming pressure, thus preventing the metal from contracting while cooling. The percent of stretch obtained by form-die quenching is proportional to the coefficient of thermal expansion of the alloy at the processing temperature.

Parts of both heavy and light gage material can be formed by this process. Since the form dies represent a large mass of metal, their surfaces remain cool during a production run of thin-gage parts. With heavy-section parts the need for rapid quenching may necessitate that the dies be cooled by circulating water through cored-out cavities beneath the die surfaces.

Parts with appreciable contour must be preformed prior to die-quench forming. Parts with extreme angles present a galling problem. Press tonnage requirements vary from part to part, depending on the size and gage of the material. For light-gage parts, 500 to 700 tons is about the minimum required (2000 to 3000 psi forming pressure).

Metallic-shot die quenching—This new forming process is directly related to the die-quench process. Major difference is the substitution of a steel container filled with 0.027 in. shot for the lower die member. (See Fig. 6.) The upper kirksite punch is cast to produce a part of clam-shell configuration. The object is to introduce the required contour in the die-quench operation and finish-form later on by bending on a press brake. The forming cycle is similar to that of die-quench forming.

Use of shot as a forming medium offers a solution to the problem of forming shallow contoured parts with machined or extruded stiffeners and sculptured areas.

In straight form-die quenching of integrally stiffened parts, success or failure largely depends on intimate part-to-die contact. But part-to-die contact is virtually impossible to obtain with mated dies unless the pressing forces are great enough to coin the irregularities of the metal.

With the metallic-shot die-quenching process, however, it is possible to achieve 100% part-to-die contact with considerably lower pressures. What's more, forming tools are simpler and cheaper.

The metallic shot does not have to be replaced, but it should be kept loose. The shot sealing problem has been solved by using a steel locating and nesting ring. This seals the shot in the die as pressure is applied and also keeps the shot from getting on top of the part.

Hydrodynamic die quenching—With this new forming process, high-pressure hydraulic pumps introduce fluid pressure into the recessed areas of a part while it is securely held in the die under ram pressure. (See Fig. 7.) Injection of fluid under high

pressure serves a dual purpose. It not only forms the part but also accelerates the quenching rate, thereby making it possible to develop higher properties in the material. The forming cycle itself is like that of die-quench forming.

This method can be very economical from a tooling and machining standpoint. It eliminates the need for (1) devices to support the skin and (2) exacting tolerances in the milled cavities. That's because slight variations are automatically compensated for by the fluid.

This information on aircraft forming was contributed by: J. S. Corral, General Foreman, Machine Forming, North American Aviation, (Panel Leader); D. W. Kraybill, Assistant Factory Manager, Tooling Operations, Northrop, (Panel Co-Leader); H. C. Emerson, Tool Superintendent, Rohr Aircraft; E. E. Carpenter, Supervisor, Manufacturing Research, Boeing; F. C. Hoffman, Manufacturing Research Engineer, Lockheed; and J. A. Cole, Tool Project Engineer, Douglas Aircraft.

(The report on which this article is based is available in full in multilithographed form, together with reports of the eight other panel sessions of the SAE Aircraft Production Forum. This publication, SP-304, can be obtained from SAE Special Publications Department. Price: $2 to members, $4 to nonmembers.)

Metallurgist and Designer . . .

. . . must collaborate closely. Through his specialized knowledge of metals and their processing, the metallurgist can render the designer invaluable aid.

Based on paper by **A. S. Jameson,** International Harvester Co.

THERE is no such thing as a designer working independently of the production man or the metallurgist. To design, manufacture, and sell a product is the job of a team and not a series of more or less independent actions by each specialist. The designer may do a perfect job of functional designing but this is of no avail if the material and processes by which it is made price it out of the market.

Let's assume that collaboration begins at the drawing board and, by way of example, that the designer specifies SAE 1045 material on the drawing. Discussion with the metallurgist can begin at this point.

SAE 1045 has several levels of strength, depending on its condition. Suppose the part is to be machined on automatic screw machines. The design engineer may not know that neither the hot-rolled material nor material heat-treated to Rockwell C 32 can be used. The hot-rolled has outside diameter tolerances too great to fit collets; the heat-treated will be too hard to machine easily.

The metallurgist will know much concerning cold-worked steel that is useful to the designer. For example, the properties for cold drawn steel are lower than can be obtained by controlled cold working. Another point, combined stresses affect the fatigue strength. In practice very few parts are subjected to simple stress, and still fewer are produced to the theoretical design. Cold working can also be obtained by shot peening and the fatigue strength is improved thereby, but the metallurgist is also involved in specifying the intensity of peening, for if not closely controlled, peening can also reduce fatigue strength.

Here's another point the metallurgist will bring out: With SAE 1045, the direction "heat-treat to 32 RC" will produce one set of physical properties in one section size and another set in another section size. If in a part larger than 1 in. in diameter the design engineer requires through the section physical properties attainable only by heat-treating to 32 RC, the metallurgist will probably recommend use of an alloy steel instead of the SAE 1045 carbon steel.

The metallurgist can also help in the problem of applying free-machining steel to production parts. There are many from which to make a selection. There are carbon steels with sulfur or phosphorus added to increase machinability. Relatively recently, lead has been added also. Sulfur and lead have also been added to alloy steels.

Certain desirable mechanical properties of screw machine steels are lost through sulfur and phosphorus additions. The longitudinal strength is unimpaired, but the transverse strength is impaired. (This "directionality" is present to some extent in all steels. Even the finest grades are somewhat weaker when stressed in a direction at right angles to the direction of rolling or stressed in torsion.) This is undesirable, for instance, in shafts subject to torque loading. Directionality must also be considered in forming sheet steel parts and in fabricating parts by forging.

The metallurgist can give advice on another item which spells success or disaster to the designed part. This is steel quality. Only parts where seams and surface defects as well as a certain amount of center segregation are to be tolerated should be specified "Merchant Quality." Special quality is usually specified for parts to be heat-treated or undergo high stresses. However, specifying "Special Quality" is insufficient. Test requirements applicable to performance of the part should also be indicated. Usually a metallurgist is required to specify properly what tests are required to insure proper quality of steel.

(Paper "How the Metallurgist Can Help the Designer" was presented at SAE Milwaukee Section, Nov. 6, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers.)

About SAE

J. F. SCHIRTZINGER is now president of the Consolidated Tool and Products Co. at Los Angeles. He was previously assistant chief engineer, administrative, at the Consolidated Vultee Aircraft Corp. in San Diego.


Schirtzinger


Rose

SAUL H. ROSE, president of Grand River Chevrolet Co., Detroit, will be guest of honor at the annual Brand Names Day banquet held at the Waldorf Astoria this month. Grand River Chevrolet has been selected Brand Name "Automobile Dealer of the Year."

JEROME LEDERER has announced that Aviation Crash Injury Research has joined and will operate as a unit of the Cornell-Guggenheim Aviation Center. Lederer is director of the Center. The purpose of this new set-up is to more closely integrate CIR's research activities in the field of aviation safety.

ROBERT J. FERGUSON is assistant engineer at the Bendix Products Division, Bendix Aviation Corp., South Bend, Indiana. Ferguson was junior engineer for the A. C. Spark Plug Division of GMC in Flint, Mich.

CARL HUNTER BOAS is now with the Sharples Research Laboratories located in Bridgeport, Pa. as a mechanical engineer. He was formerly with the U. S. Department of Agriculture's research lab in Philadelphia.

JAMES ARTHUR RICE has become special assignments engineer for Canadian Pacific Airlines Ltd., Vancouver, A.M.F., British Columbia. Rice was previously chief engineer for the Queen Charlotte Airlines, Ltd., Vancouver, A.M.F., British Columbia.

J. H. DUNLOP, previously plant superintendent at Wix Accessories Corp., Toronto, Ontario, Canada, is now plant manager for Filtron Ltd., Waterloo, Ontario.

SAE Father and Sons . . .

OTTO E. KIRCHNER (center) is director of operational engineering, American Airlines. His sons, who have inherited their father's aeronautic interests, are both with Boeing Airplane Co. in Seattle. **MARK E. KIRCHNER** (left) is an aerodynamicist and **OTTO E. KIRCHNER, JR.** (right) is with Boeing's systems analysis department.

Members . . .

HARLOW H. CURTICE, president of General Motors, was subject of the "Who's Who in Michigan" column of "The Detroit News" last March 15.

PAUL E. TOBIN, manager of the North Atlantic region for The White Motor Co., has been named a judge in the annual visual sales presentations awards now being conducted by the National Visual Presentation Association. The program is cosponsored by the Sales Executives Club of New York of which Tobin is a member.

CARROLL K. McCULLOUGH will now devote him time to consulting activities. McCullough was formerly president and director of The Pierce Governor Co., Inc., Anderson, Indiana.

H. L. RITTENHOUSE, manager, product engineering, has written that the Euclid Road Machinery Co. is now the Euclid Division of GMC, Cleveland.

WILMER H. CHURCHILL has been elected vice-president of United-Carr Fastener Corp. Churchill has been chief product engineer for the company for many years and will continue in the same capacity at the Ames Street plant in Cambridge, Mass.

Churchill

Larson

CLIFFORD M. LARSON, chief consulting engineer for the Sinclair Refining Co., New York, has been given a thirty-five year service pin for his work at Sinclair.

BURT C. MONESMITH, vice-president and general manager of the California Division of Lockheed Aircraft, addressed the Lockheed Management Club in California at the Hotel Statler, March 15.

STEVEN SCHNELL has become manager of advanced engineering for the Wagner Electric Corp. in St. Louis, Mo. He was manager of hydraulic and industrial brake development for Wagner.

Changes at Caterpillar

Neumiller

Eberhard

LOUIS B. NEUMILLER has become board chairman of the Caterpillar Tractor Co., Peoria. He was president. **H. S. EBERHARD**, who has been executive vice-president of Caterpillar, is now president.

Neumiller has been president of the company for the last 12 years. Both men have been with Caterpillar since they first entered industry, Neumiller as a stenographer-clerk, and Eberhard as a draftsman in the Stockton, Calif., plant.

Neumiller was toastmaster at SAE's Annual dinner last January.

K. C. BAKER, president of J. D. Streett & Co., Inc., St. Louis, Mo., is a members of the new Meeting Assistance Committee established by the Division of Marketing of the American Petroleum Institute. The objective of the new committee is to assist, upon request, in obtaining talent for programs of jobber, dealer and other association meetings attended by oil marketing people anywhere in the country.

ROBERT B. HAWKINS is now regional manager for Sterling Aluminum Products, Inc., St. Louis, Mo., with offices at 260 Briggs Building, Birmingham, Mich. Hawkins was manager of the Detroit office for Sealed Power Corp., Muskegon, Mich.

FORREST WORTH COOK is an engineer for Carter Carburetor Corp., St. Louis, Mo., He was resident engineering representative for the same company.

RICHARD C. CARSON has been elected vice-president, charge-of-engineering for Shuler Axle Co. of Louisville, Ky. He was sales manager for Shuler.

Carson

Crankshaw

JOHN H. CRANKSHAW has been promoted to vice-president in charge of engineering at J. A. Zurn Mfg. Co. and its affiliates, American Flexible Coupling Co., and the Zurn Research and Development Co., of Erie, Pa. Crankshaw was formerly executive engineer for the American Flexible Coupling Co.

Lockheed's Selling Functions Reassigned


Thomas

CHARLES F. THOMAS remains corporate director of military sales in the reassignment of military sales functions at Lockheed Aircraft Corp. Now direct selling functions have been assigned to the individual divisions of the corporation, and the head of military sales in each division will have charge of the direct military selling program for his division's products.

Thomas will provide advice to corporate management and the operating divisions on government organization and practices, military budgets and appropriations, and other matters of a planning and sales-control nature. He will also help coordinate over-all military sales planning for the divisions and assist in contact work with government officials. Advising management with regard to new projects and products and their assignment to the operating divisions for development and sales promotion, will be part of his function, as well.

W. G. MYERS has been named head of military sales for the Georgia Division. He was manager of the contract department.

EDGAR H. DIX, JR., assistant director of research, Aluminum Co. of America, has received the Frank Newman Speller Award of the National Association of Corrosion Engineers. The Speller award is given annually by NACE in recognition of achievement in corrosion engineering.


Dix


Sadler

CARL L. SADLER, formerly chief engineer of the Hydraulic Division, has been promoted to manager of the new Aviation Division of Sundstrand Machine Tool Co., Rockford, Ill. Sundstrand's former Hydraulic Division has been divided into two completely segregated entities, the Aviation Division (to be known as Sunstrand Aviation, Division of Sundstrand Machine Tool Co.) and the Industrial Division.

Sadler is a member of SAE's Aircraft Activity Committee and chairman of the Accessories and Equipment Division of the Aeronautics Committee.

H. O. MAINZINGER has retired as sales manager of the Agricultural Division of The Budd Co., Detroit.

MAURICE MICHAEL WELSH, formally quality control engineer for Nash-Kelvinator Corp., Detroit, is now learning methods of operation in various departments and plants of Nash-Kelvinator in a management training program.

J. H. FAMME has been promoted to assistant chief engineer at the Consolidated Vultee Aircraft Corp., San Diego. He will fill the vacancy left by the death of **N. W. BOULEY.** He will have responsibility for the project, flight, and service sections. Famme was formerly chief project engineer.


Famme


Feldman

HYMAN FELDMAN has become assistant general superintendent for the New York Transit Authority. Feldman was previously automotive maintenance supervisor for the Capital Transit Co., Washington, D. C. He is a member of SAE's Transportation and Maintenance Activity.

DON A. DULING is manager of the Helena, Montana, district for The Carter Oil Co., Helena. Duling was formerly Paramins salesman representing the Enjay Co., Inc., Carter Oil Co.

DAVID BORODAWKIN is now with Infilco, Tucson, Arizona, as a mechanical draftsman. He was previously junior mechanical engineer for Continental Engines in Detroit.

GEORGE F. NOLTEIN has retired as consulting engineer for The National Supply Co., Engine Division, Springfield, Ohio. Noltein will now reside in Tampa, Florida.

GURDON LUCIUS TARBOX has retired as chief test engineer of the Spicer Manufacturing Division of Dana Corp., Toledo. He now resides at Georgetown, S. C.

JOHN D. TEBBEN has been elected president and board chairman of the recently organized Wagner Bros. Equipment Co., Wayne, Mich. The firm was formed by a group of employees of Wagner Bros., Inc., manufacturers and warehouse suppliers to the plating industry.

Tebben, who has been connected with Wagner Bros., Inc., for the past year, has been a management consultant for many firms as head of John D. Tebben & Co. He is vice-president and director of Wagner Bros., Inc.


Tebben


Ayres

VINCENT AYRES has been promoted to chief engineer, Saginaw Division, Eaton Mfg. Co., Detroit. Ayres was an assistant chief engineer for Eaton. He is the present chairman of SAE's Membership Committee. He is also a member of the Public Relations Committee, the Passenger Car Activity, and the Truck & Bus Activity. Besides all his committee work, Ayres has been the author of several papers on valves.

LUCIANO F. MOLINARI has joined Republic Aviation Corp., Farmingdale, N. Y., as a designer "B". He was a design engineer for North American Aviation, Los Angeles.

Continued on Page 108

Obituaries

CHARLES STALLWOOD

Charles Stallwood, 42, assistant chief metallurgist at the Allison Division, GMC, died January 8.

Stallwood had been with Allison since 1935, the same year he entered General Motors Institute. He was at the Institute from '35 until '39, studying automotive engineering. He had also taken electrical engineering courses at Purdue.

He was born at Birmingham, England, but became a naturalized citizen of the U. S.

CHARLES HARRISON WARNER

Charles Harrison Warner, assistant to the president, Clark Equipment Co., Washington, D. C., died March 6. He was 57.

Warner had been with Clark Equipment since 1945, handling all company matters with the U. S. Government and foreign agencies.

During World War II he was with the Army in Washington as Army representative for the Joint Electronics Agency. Prior to the war, he was an investment officer for the Security National Bank, Battle Creek, Mich.

His other experience was as secretary-treasurer of Bondex, Inc., Chicago; investigator and negotiator for Theodore Gary & Co., Kansas City, Mo., Chicago and New York; and owner-manager of the Rossville Telephone Co., Rossville, Ill.

Warner attended Northwestern University where he received the B.S. degree. He later studied automatic telephone engineering at the Automatic Electric School in Chicago. He was a native of Illinois, born in Rossville.

D. MYRLE SMITH

D. Myrle Smith, director of industrial sales and a member of the board of directors of the McQuay-Norris Mfg. Co., died February 3 in St. Louis, Mo. He was 58.

Smith had been with McQuay-Norris for over 30 years. He joined the company in 1920 as assistant chief of the piston ring plant and later was made works manager of the St. Louis Plant before becoming industrial sales manager for all plants, including the Electric Products Division. Previously he had been with the Elliot Co. doing sales engineering, with Goodyear Tire & Rubber Co. working at production control, and at Sloan-Huddle-Faustel & Freeman, consulting engineers, doing appraisal work.

He received his education at Purdue University from which he received his B.S. degree in mechanical engineering. He was born at College Corner, Ohio.

RALPH LEX ADAMS

Ralph Lex Adams, 65, automotive body engineer, died January 20.

Adams entered industry with the J. G. Brill Co. in Philadelphia as a draftsman and designer. He was with Brill until 1917, when he joined the Edward G. Budd Mfg. Co., also in Philadelphia. His specialty was designing motor truck bodies.

Adams was born in Philadelphia and attended the city's public schools. Later he went to Drexel Institute where he took mechanical drawing and engineering courses.

He was a member of the Society for over 35 years.

T. C. HUXLEY, JR.

T. C. Huxley, Jr., vice-president and Western sales manager of Diamond T Motor Car Co., died February 3 from cerebral hemorrhage. He was 63.

In his capacities as regional sales manager and for eight years as director of sales for Diamond T, Tom Huxley had become a national figure in the industry, with friends and admirers in every part of the country.

He began his business career in 1918 as retail salesman for Garford Co., Seattle. The following year, he joined the Diamond T organization and was soon district manager for Oregon and Washington. With the rapid expansion and development of trucking during the first post-war boom, his activities increased and his territory was enlarged until it included all Western states and part of Canada.

The business recession of 1920 brought forth an intensive drive for increased sales. At this time Huxley was called to the factory and assigned to the management of national accounts. His duties also included district work in the Illinois area, where he demonstrated merchandise that could be moved.

His selection as manager of the New York branch came in the latter part of '22. Later, when Diamond T management decided the factory branch system of distribution did not function with maximum efficiency, he was given responsibility for developing a comprehensive dealer organization in the Eastern area. He was made vice-president and Eastern sales manager at that time.

During World War II, Diamond T converted to military production, and Huxley took charge of all military field service maintenance. After the war, C. A. Tilt, founder and president of the company, retired from active direction and became chairman of the board. E. J. Bush, previously vice-president and sales manager, became president, and T. C. Huxley moved to Chicago to take charge of sales for the entire country.

He continued as sales manager, and became director of sales until the summer of '53. At that time, because of his health, he moved to the Pacific Coast as Western Division sales manager.

De ALTON MARTIN

De Alton Martin, general manager and partner of Nebraska Propane Gas, Inc., Kearny, Nebraska, died December 22. He was 31.

Before he became manager and an owner of Nebraska Propane in 1951, Martin was general manager of a branch office of the company. As branch manager, he promoted the use of propane as fuel for internal combustion engines in farm tractors, trucks, and cars.

He was a native of Oklahoma, born at Shawnee. He attended high school in Graham, Okla. Two years after high school graduation, Martin was a pilot in the U. S. Air Force. His secondary duty was maintenance and engineering. He graduated from the aviation cadet course at Williams Field, Phoenix, Arizona.

At the time Martin applied for membership in SAE, he was described as "reliable and energetic," with a "pleasant disposition."

CYRIL HENRY BARTON

Cyril Henry Barton, 56, chemist in the products applications department of the Shell Oil Co., died December 10, 1953.

Prior to joining Shell, Barton was with Asiatic Petroleum Co., Ltd., as an assistant research chemist doing special investigation work on petroleum, especially on gasoline and lubricants. He had also been an assistant chemist with the Anglo-Mexican Oil Co., Ltd., London.

Barton was born in England at Smethwick, Staffs. He attended King Edward's High School, Birmingham, England; Jesus College, Cambridge; and Cambridge University. At Jesus College he studied chemistry and physics, receiving a B.A. degree. At Cambridge, he obtained a Master's degree.

Besides SAE, Barton was a member of the Institute of Chemistry. He was also the author of several papers for SAE.

SAE Student News

University of Pittsburgh

The SAE Student Branch has been chosen "the most outstanding engineering society" at the University of Pittsburgh, and The Stephen Foster Memorial has been presented to the Branch in recognition of its activities. Ralph Knapp, past chairman, and Robert Varga, present chairman, received the award on behalf of the Branch members at an engineering department assembly last January 14.

This is the first time the Stephen Foster Memorial has been presented. It is a plaque consisting of the University Seal and rows of blank name plates—except for the first which is inscribed "SAE." In order to have permanent possession of the plaque, an organization must win the award three semesters in succession. This undoubtedly will be the students' goal.

Pitt's SAE Branch was organized in '51 under the supervision of Professor Norman H. Wackenhut, the advisor. During a typical semester, the agenda includes field trips to industrial plants, speakers from industry, and a few social events.

University of Oklahoma

Although jets offer higher speeds and improved service, the conventional air liner is likely to be in use for some time, according to W. C. Lawrence at the March 5 meeting. He is director of development engineering for American Air Lines, New York.

In his paper, "The Place of the Turbojet in Commercial Air Lines," he pointed out the chief objections to this type of craft from the standpoint of the commercial airlines: high cost, high fuel consumption, low take-off thrust and noise produced when near the ground, as well as at cruising speed. However, he did admit that future developments and competition could alter the viewpoint now held.

As an added attraction at the meeting, candidates for "Engineers' Queen" were introduced. The meeting was conducted by John Borden, student chairman. Floyd E. Selim, Mid-Continent Section Chairman introduced the speaker.

Award Given to Pittsburgh Branch

"For the most outstanding engineering society" at the University of Pittsburgh, the Stephen Foster Memorial award is received by Student Chairman Bob Varga (extreme right) on behalf of the Branch. Dalton Kerr, vice-president of the Senior engineering class, presents the award. Prof. Norman Wackenhut, Branch advisor, is at extreme left, next to him Prof. N. Lewis Buck, head of the mechanical engineering department, and to the right of Prof. Buck is Dr. G. R. Fitterer, Dean of the Schools of Engineering and Mines.

University of Saskatchewan

SAE's Branch at Saskatchewan has had such interesting speakers this year that attendance at meetings was almost double the number of enrolled student members. Businessmen and professors swelled the ranks.

The history of motorcycles was the subject presented at the October meeting by Bernie Nicholson of Nicholson Bros. Motorcycle Shop in Saskatoon. R. W. Frayling of the Firestone Tire Co. talked on tire construction and wear at the November meeting.

Sports cars took the spotlight in December with a talk from Don Shaw of Merlin Motors, Saskatoon, and for February Blythe Simpson of the Rootes Motor Co. outlined the history of Britain's automotive industry. Last March Bert Lepine spoke on the evolution of piston rings. He is with the Perfect Circle Piston Ring Co.

New officers for the Branch are: Chairman John Rae, Vice Chairman Glen Pearson, Secretary-Treasurer Bill Orge, Program Director Dick Critchley, Publicity Director Jack McManus, and Membership Director Elgin Horton.

Purdue University

The Indiana Section met with the Student Branch of Purdue University for the Annual Dinner Meeting, March 11. J. H. Dunn, manager of the Development Division of the Aluminum Co. of America discussed "Light Metals in the Car of the Future." Dunn highlighted his paper by building the skeleton of "tomorrow's auto" with aluminum and magnesium parts.

Rolla School of Mines and Metallurgy

Members of the SAE Student Branch journeyed to St. Louis last March 5 to gain knowledge of mass production in the automotive field. The students were guests of the Chevrolet Assembly Plant.

A. F. Dames, director of personnel, arranged the trip and the students were divided into small groups to be shown through the plant.

Guides discussed and answered questions concerning various aspects in the production assembly of automobiles.

(Rolla Mar. 5)

A journey to Chevrolet's assembly plant in St. Louis was made by members of SAE's Student Branch at the Missouri School of Mines and Metallurgy, Rolla, Mo., last March 5. The picture shown above was taken in front of the plant.

Indiana (Mar. 11)

The engine of the car of the future is seen by members of Purdue's Student Branch and Prof. O. C. Cromer, (third from left), advisor. The engine is made of aluminum and magnesium parts and was used to illustrate J. H. Dunn's paper, "Light Metals in the Car of the Future," last March 11. Dunn is fifth from left.

Students Enter Industry

LYNN KEITH (Northrop Aeronautical Institute '53) is a weight analyst for North American Aviation, Inc. He is at the Downey plant in California.

GEORGE L. GOOD (General Motors Institute '54) is with the Fisher Body Division of GMC, Detroit, as a labor standards analyst.

WILLIAM BREITBARTH (Bradley '53) is now serving in the armed forces. Breitbarth is a lieutenant with the 3337th Technical Training Squadron, stationed at Scott Air Force Base, Ill.

BENNIE SHULTZ, JR. (University of Oklahoma '53) has been transferred to the appliance motor department of General Electric at De Kalb, Ill. He was with GE in Schenectady, N. Y.

RONALD GENE CORDER (Texas A & M '54) is a research and development engineer for Boeing Airplane Co., Seattle.

KAMIL YIGIT (State University of Iowa '54) is an engineer for the Minneapolis-Moline Co. in the automotive engineering department.

RAYMOND D. GUIDOS (University of Pittsburgh '54) is a test engineer for the General Electric Co., Fort Wayne, Ind.

JACK S. MILLER (University of Texas) is employed by the Pratt & Whitney Division of United Aircraft in East Hartford as an installation engineer-trainee.

GEORGE V. McGAHA (Clemson '54) has joined R. H. Bouligny, Charlotte, N. C., as a mechanical engineer.

EMMETT S. IVERSON (Purdue University '54) is serving as a captain with the U. S. Air Force. He is stationed at Edwards Air Force Base, California.

ROBERT H. BILES (California Institute of Technology) is with the U. S. Army, Battery B, 51st FA Battalion.

EDWARD H. PARKER (Fenn College '53) is a junior engineer for Douglas Aircraft Co., Inc., Santa Monica, Calif.

ROSS M. HAUN (General Motors Institute '54) is a process engineer for McKinnon Industries, Ltd., St. Catharines, Ontario, Canada.

SAE Section Meetings

Atlanta—May 17

Ship-A-Hoy Restaurant. Dinner 7:00 p.m., meeting 8:15 p.m. Combined meeting with IAS. R. R. Teetor, president, Perfect Circle Corp.

Buffalo—May 18

Transit Valley Golf Club. Dinner 7:00 p.m., meeting 8:00 p.m. European Car Design and Influence on American Cars—Maurice Olley, director of research and development, Chevrolet Div., GMC, Detroit, Mich. Golf during afternoon. Sports car display.

Canadian—May 28

Genosha Hotel, Oshawa, Ont., Canada. Dinner 6:30 p.m., meeting 8:00 p.m. Fibre Glass. Speaker to be announced.

Central Illinois—May 17

American Legion Hall. Dinner 6:30 p.m., meeting 7:45 p.m. Gas Turbine Power for Earthmoving Equipment—Henry Hill, assistant chief project engineer, Boeing Airplane Co., Seattle, Wash. Coffee Speaker—Theo. Litchfield.

Chicago—May 11

Hotel Knickerbocker, Chicago. Dinner 6:45 p.m., meeting 8:00 p.m. Super Tires for Super Roads—T. A. Robertson, manager truck and tractor division, development department, Firestone Tire & Rubber Co. Social Half-Hour 6:15 to 6:45 p.m. Sponsor to be announced.

Cincinnati—May 24

Engineering Society of Cincinnati. Dinner 6:30 p.m., meeting 8:00 p.m. Oil Industry Information Committee Presentation of the Magic Barrel—Jack Goodnight, industrial engineer, Standard Oil Co. (Ohio), Cincinnati, Ohio.

Cleveland—May 10

Jack & Heintz, Inc., Bedford, Ohio. Dinner 6:30 p.m., meeting 7:30 p.m. Generators for High Performance Aircraft—C. G. Martin, project engineer, Jack & Heintz, Inc. Plant tour of Jack & Heintz before dinner.

Indiana—May 20

Marott Hotel, Indianapolis, Ind. Dinner 7:00 p.m., meeting 8:00 p.m. Auto Racing in Europe and America—Lee Oldfield, engineering consultant, Laboratory Equipment Corp.

Metropolitan—May 21

Knollwood Country Club, Elmsford, N. Y. Sponsored Cocktail Hour. Dinner and Dancing. Golf, bridge, games for all. Prizes for all events. Tickets $10.00 per person.

Mid-Continent—May 14

Tulsa, Okla. Ladies Night.

Milwaukee—June 5

Ozaukee Country Club, Thiensville, Wisconsin. Dinner 7:30 p.m. Ladies Nite Party.

Mohawk-Hudson—May 14

American Locomotive Club, Schenectady, N. Y. Meeting 8:00 p.m. Ladies Night. Movies, entertainment, dancing, buffet supper.

Montreal—May 17

Chateau Laurier, Ottawa, Canada. Dinner 7:00 p.m., meeting 8:00 p.m. J. L. Gray, vice-president adminstrations and operations, Atomic Energy of Canada, Ltd., Ottawa.

New England—June 7

Woodland Country Club. All day annual outing. Dinner 8:00 p.m. Gala Event of our year.

Oregon—May 14

Corvallis, Oregon. Dinner 6:30 p.m., meeting 7:30 p.m. Lubrication and Combustion—Lloyd M. Landwehr, automotive engineer, The Texas Co., Seattle, Wash.

Philadelphia—May 21

Spring Haven Country Club. Social Hour 6:30 p.m. Dinner and Dance. Dinner 7:30 p.m. Ladies Night. Card parties and golf.

Pittsburgh—May 19

Wenango Country Club, Oil City, Pa. Dinner 6:30 p.m., meeting 8:00 p.m. Recent Developments in Sports Cars—Earl Monson, chief development engineer, Nash Kelvinator Corp., Kenosha, Wisconsin.

St. Louis—May 11

St. Louis, Mo. Dinner 7:00 p.m., meeting 7:45 p.m. Suspension Tandem Axles in Commercial Vehicles— N. R. Brownyer, vice-president, Timken Detroit Axle Co., Detroit, Mich. Special Feature: Our little copper eating pig will find his (or her) permanent home at this meeting.

Southern New England—May 21

Wethersfield Country Club, Wethersfield, Conn. Dinner 7:00 p.m. Spring Social Meeting.

Texas—May 21

Italian Village Restaurant. Dinner 7:30 p.m., meeting 8:15 p.m. Suspension of Dual Wheel Axle—N. R. Brownyer, vice-president, Timken Detroit Axle Co., Detroit, Mich.

Twin City—May 12

Solarium Room, Curtis Hotel. Dinner 6:30 p.m., meeting 8:00 p.m. The New Packard Lightweight Diesel Engines—R. E. Taylor, assistant chief engineer, Packard Motor Car Co., Detroit, Mich.

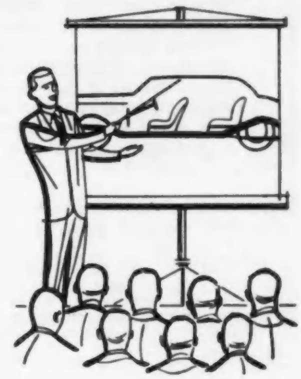
Williamsport—June 7

Moose Club. Dinner 6:45 p.m. Ladies Night.

This is not a complete list of all Section Meetings. It includes only those meetings for which we have received sufficient advance notice to permit listing.

SAE SUMMER MEETING

June 6-11, 1954
The Ambassador Hotel, Atlantic City, N. J.



• TECHNICAL SESSIONS

will focus on current problems, such as . . .

- How can we improve truck stopping ability?
- What are the new non-destructive testing methods?
- Why is the Napier aircraft diesel so promising?
- What's being done to curb vapor lock?

• ROUND TABLE DISCUSSIONS

will probe the how-to of . . .

- Automotive air conditioning design
- Reducing manufacturing costs
- Suppressing car noise
- Testing aircraft jet engines
- Overcoming preignition and knock

• SPECIAL EVENT! ! !

One entire session devoted to gas turbine-powered ground vehicles. One display will be the Firebird car and a heavy vehicle, both powered by turbines.

• SPORTS AND SOCIAL ACTIVITIES

Swimming, golf, dancing and other recreational events

FIRST BUCKENDALE LECTURE . . .

to be presented in August by Dodge's K. W. Gordon at Rackham Building.

KENNETH W. GORDON, a project engineer in Dodge's Truck Division, has been selected to be the first L. Ray Buckendale lecturer. His lecture will be delivered in late August . . . at the Rackham Building in Detroit.

There, at an SAE Detroit Section meeting, sponsored by Junior and Student Activities, Gordon will speak on "Design, Evaluation, and Selection of Heavy-Duty Rear Axles."

This lecture is scheduled to be presented to young engineers because one of L. Ray Buckendale's cardinal interests was developing the latent abilities in young men.

A major objective of the lecture is to provide young engineers with up-to-date design information not generally available in textbooks.

In keeping with this thought, Gordon intends to lay down "ground rules" for the design, evaluation, and selection of automotive axles.

Design problems pertinent to the four chief functions of an axle will be discussed . . . and some useful approximations outlined. Gordon will delve into (1) axle ability to carry load, (2) axle capacity to transmit driving force, (3) matters pertaining to the differential, and (4) the system for producing deceleration.

Kenneth W. Gordon

SAE National Meetings . . .

1954

June 6-11
Summer Meeting
The Ambassador,
Atlantic City, N. J.

August 16-18
National West Coast Meeting
Hotel Statler, Los Angeles, Calif.

September 13-16
National Tractor Meeting & Production Forum
Hotel Schroeder, Milwaukee, Wis.

October 5-9
National Aeronautic Meeting,
Aircraft Production Forum, and
Aircraft Engineering Display
Hotel Statler, Los Angeles, Calif.

October 18-20
National Transportation Meeting
The Sheraton-Plaza
Boston, Mass.

October 26-27
National Diesel Engine Meeting
Hotel Statler, Cleveland, Ohio

November 4-5
National Fuels and Lubricants Meeting
The Mayo, Tulsa, Okla.

1955

January 10-14
Golden Anniversary
Annual Meeting and
Engineering Display
The Sheraton-Cadillac Hotel and
Hotel Statler, Detroit, Mich.

March 1-3
Golden Anniversary
Passenger Car, Body and
Materials Meeting
The Sheraton-Cadillac Hotel,
Detroit, Michigan

March 14-16
Golden Anniversary
Production Meeting
Netherland Plaza, Cincinnati, Ohio

April 18-21
Golden Anniversary Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display, Hotel Statler and McAlpin Hotel, New York, N. Y.

from the Sections

Future aircraft design has been a popular recent subject at the Sections. . . . At Met Section, President William Littlewood suggested transports with two main loading doors and with door-type emergency and service exits. Jerome Lederer, director of the Flight Safety Foundation, New York, brought St. Louis members up-to-date on advances being made in design from the safety standpoint. The Navy's needs in aircraft engine design was described for Southern New England Section by J. Denny Clark of the Bureau of Aeronautics, and in designing engines for jet transports, Fred Glass told Southern California Section members he thought CAA standards will be the guide to be followed. Glass is director of the aviation department of The Port of New York Authority.

Cincinnati

Field Editor
L. B. Lohaus
Mar. 22

DYNAMOMETERS WITH CAPACITIES UP TO 35,-000,000 FT-LBS are now in use that can test large truck brakes and railway brakes. This fact was brought out by Don Rohrer in his paper, "Friction Materials." Rohrer is chief research chemist of the Grey-Rock Division, Raybestos-Manhattan, Inc.

An interesting device on these machines, Rohrer said, is **the Unitork valve** which regulates input pressures so that output torque is always maintained at the same predetermined figures. "Thus in each brake application the same amount of work is done and results are strictly comparable."

He pointed out, too, how variations in usage broadly affect the life of a friction material:

"In developing **Veelok facings** we tested them on the clutches of the same model of Yellow Coaches. In Kansas where the country is flat and clutches are used at long intervals, 125,000 miles per installaation were obtained. In Pittsburgh with typical hilly country only 30,000 miles. But on Fifth Avenue, New York, with the clutch in almost constant use the mileage was reduced to only 5,000 or 6,000. —Simply a matter of longer continued use at higher temperatures."

Rohrer said that from time to time there appear on the market materials which are to be applied to the surface of brake linings or clutch facings to improve friction and lengthen the life of friction materials. "There is absolutely no improvement by their use and in some cases they **can be dangerous,**" he said.

Southern New England

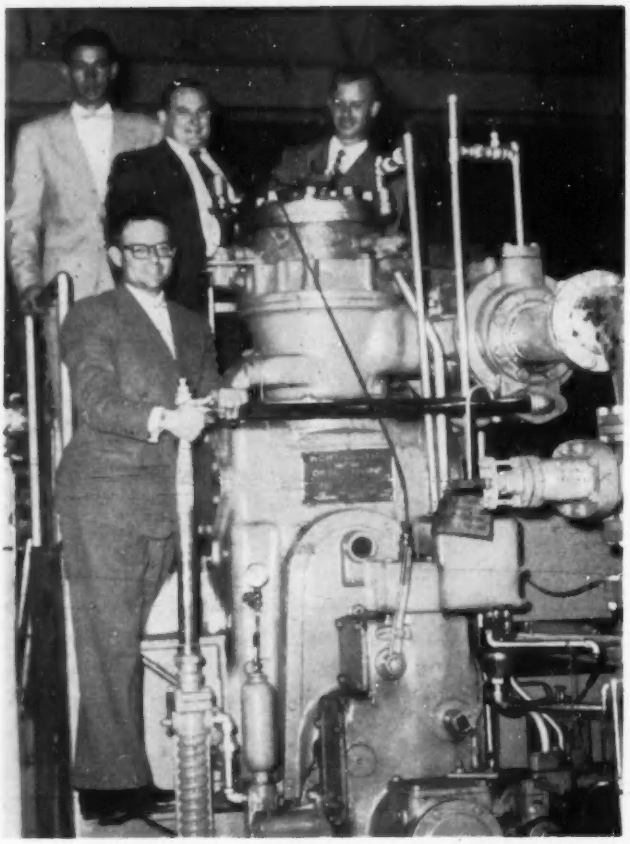
Field Editor
A. D. Nichols
Apr. 6

TURBOJETS WILL BE USED IN NAVAL AVIATION more and more, according to J. Denny Clark of the Bureau of Aeronautics. But Clark does not expect the jet engine to completely supersede the propeller-driven plane in the near future. He said that the average **operating life** from 300–400 hr between overhauls is still too low.

Clark told the Section that the Navy is interested in **eliminating "gadgetry"** wherever possible and consistent with safe operation. "We have discovered that automatic features are the frequent cause of engine malfunction, particularly when operating at "off-design" conditions.

He thought that any action taken by engine designers to make their engines less susceptible to damage by foreign objects will be welcomed. Al-

Northern California (Mar. 24)



From Section Cameras

Perched on diesel are members with student guides on a tour of the engineering facilities at the University of California. The tour preceded the annual student meeting.

Examining the 1898 Toledo automotive steam engine are: (left to right) James Dutzi, University of California; Richard Canzoneri, California Polytechnic College; J. A. Edgar, chairman of the Northern California Section, and Richard Kern, University of Santa Clara. The three students presented papers at the annual student meeting.

though the Navy is doing everything it can to eradicate the sources of foreign objects, he doesn't think such objects can be entirely eliminated. While the cost of new engines will be a factor, quality, reliability, improved fuel consumption and ease of maintenance will be the criteria for the **selection of new engines.**

Western Michigan

Field Editor
C. E. Messner
Feb. 16

COLORFUL BUS INTERIORS that are attractive and restful are in the offing. That was the opinion of E. F. Lewis, Coach Sales Division of GMC.

Lewis said that in the past drab colors have been selected because they would not readily show an accumulation of dirt. There is also an increasing trend toward **tinted glass** for both city and highway use to reduce sun glare and improve comfort.

He said, too, that heating and **ventilation systems** are being improved, providing continuous changes of filtered air and controlling temperatures within limits enjoyed in the home or modern automobile. Highway coaches are now equipped with efficient heating and air conditioning systems, using the same ducts and outlets to provide the most desirable distribution. They are controlled through the same thermostat.

Kansas City

Field Editor
R. Spencer
Mar. 26

LONGER COMBUSTION AND DIESEL ENGINE LIFE was the subject of Paul E. Daugherty of Cummins Diesel Engine Co.

Daugherty stressed the importance of proper break-in (which will result in lower maintenance costs), prevention of entrance of dirt into engines (for less wear), abnormal combustion of fuel, operating temperatures, and proper fuel injection.

Detroit

Field Editor
D. T. Roberts
Jan. 25

HIGH-SPEED PHOTOGRAPHY does not necessarily entail a large cash outlay. Approximately $5,000 is just about all that is needed to get started. That's what Ellis Rifkin, research supervisor for the Ethyl Corp. said at the Section's panel meeting for the Junior Activity. The subject was, "Photography in Automotive Engineering."

Panel member Bill McCarthy, research engineer for Ford, told the group how Ford used photography in solving **stress distribution** problems and also how the spectrograph is used in chemical analysis. Frank Thomas of Chrysler told of the excellent results obtained with modern photomicrography methods.

Robot cameras for recording pilots' field of vision, the use of the polaroid Land camera for quick results, and **streak photography** to record motion of automobile suspension systems were also discussed.

Members of the discussion panel were: Michael C. Turkish of Eaton Mfg. Co.; Worth H. Percival of GMC's Research Labs Division; Louis C. Lundstrom of GMC's proving ground at Milford, Mich.

Jim Pilz of Timken Roller Bearing Co. was moderator.

Southern California

Field Editor
W. E. Achor
Feb. 11

AIRPORTS CANNOT "PLAY LEAP FROG" with the aircraft designer. "They cannot continue to add another thousand feet of runway every time the designer's slip stick turns out a new airplane. Those days are gone—They're gone forever." This is the opinion of Fred M. Glass, director of the aviation department of The Port of New York Authority.

"The present cost of airport construction and the **zoning requirements,** the acquisitions, and the expansion of operations means that when an airport is to be expanded, runways extended, properties made larger, it is going to require much more comparent situations than a given transport aircraft coming off the line which would like to have another 750 ft of runway."

Basic **CAA standards** are in effect now which establish the lengths of runways, particularly for intercontinental airports. These standards, he thinks, are going to be the guide that will have to be followed in the design of **jet transports** and all transports, at least for the foreseeable future.

Concerning the noise problem, he thinks the "... first great burden falls upon the airline and the manufacturer—both airframe and powerplant"—in determining specifications and basic design for **noise levels** acceptable to the man outside the airplane.

Mar. 18

"MANY TRANSPORTATION COMPANIES ARE OPERATING WITHOUT RECORDS to show exactly how they are spending 25% or more of their revenue dollar." This is what La Verne Morgan, Oakland plant manager of Edward R. Bacon Co., told members.

Morgan said this is approximately the average figure determined by the findings of the Interstate Commerce Commission.

"Unless the company's operation is unusual, the maintenance department has grown without any plan. Equipment was purchased and because of the convenience, the decision was made to hire a mechanic to care for it. . . . No one was interested in exactly how the equipment was maintained as long as profits were good. Sometimes the maintenance costs were given **the 'shot gun' treatment.** 'They are too high, cut 'em.' Just where or why they were

From Section Cameras

Milwaukee (Apr. 2)

Happy trio is: (left to right) Section chairman C. L. Spexarth; Commander J. J. McMullen, USN (Ret.), now with Hudson Engineering Co., who was main speaker at the Section's April meeting; and J. W. Mohr, Section program chairman for 1953–54. McMullen's paper was, "Performance of Free Piston Gas Generators."

Hawaii (Mar. 15)

All aboard the USS Reclaimer are: Engineman first class Yarnell L. Cooper, USN, who told SAE members about the use of salvage equipment aboard the ship. Members above are: (left to right) Drury Adams, division representative for Shell Oil; George M. Wheelwright, vice-president in charge of the Auto Supply Division, Motor Supply, Ltd; and Kenneth M. Watson, superintendent of maintenance, Oahu Transport Co., Ltd. Seventy-four members toured the vessel at Pearl Harbor where Lt.-Com. Howard Smith spoke on problems and operation of the ship.

too high or how they were cut wasn't too important."

Morgan suggested that a well-planned maintenance program should consist of the following:

1. A schedule of all **routine checks** from daily inspections to major rebuild
2. A log of the work performed on each vehicle
3. A record of emergency repairs
4. A tire **failure analysis**
5. A cost accounting report which will allow comparing the cost of individual vehicles with the fleet average
6. A sumary sheet showing **the total cost** of each item of maintenance

Mohawk-Hudson

L. F. Smith
Field Editor
Mar. 9

OVER 50,000 HOURS OF DYNAMETER TEST RUNNING were required to develop the '54 Mercury engine, according to Paul M. Clayton. He is assistant engineer, engineering, at Ford in Dearborn, Mich.

Some other statistics brought out by Clayton were:

1. 175 test engines were built,
2. 125,000 man-hours were expended, and
3. **600,000 vehicle** test-miles were accumulated.

A stiffer crankcase (made possible by extending the case below the crankshaft centerline) was among the more important improvements, Clayton said. Because of this change, a flat surface to which the shallower pan could be bolted became possible, insuring **a good seal.**

Clayton said that by using more overlap on the crankshaft (made possible by the shorter stroke), the crankshaft was stiffened. This raised the frequency of the serious critical above maximum operating rpm.

Washington

Field Editor
C. Janeway
Mar. 16

A SPEED OF 19,000 MPH is needed to travel in an orbit about the earth according to John L. Sloop, chief of the Lewis Flight Propulsion Lab, Cleveland. Sloop is primarily concerned with increasing speed and range of rockets in his research work with the NACA.

A practical solution of attaining high ratios of weight full to weight empty in rockets, is through **multiple staging,** Sloop said, since rocket velocity is proportional to velocity of the gases and the weight ratio. A speed of 1700 mph is attained before the first stage is rejected, 8300 mph before the second stage is rejected, and a top burn-out speed of 25,000 mph can be obtained before the fourth stage is rejected.

Sloop thinks that hydrogen-fluorine is the best of various **rocket fuels** to date. He also believes that high skin temperatures are less a problem than popularly believed because maximum missile velocities occur in a less dense atmosphere. Use of propellent liquid as a film coolant has been able to keep **skin temperatures** to a safe limit, he said.

Milwaukee

Field Editor
D. R. Neeld
Apr. 2

A MULTIPLICITY OF APPLICATIONS is the advantage of the free piston gas generator according to Commander J. J. McMullen, USN (Ret.), now with the Hudson Engineering Co.

In France, McMullen said, the Sigma Model GS-34, based on the original patents of Pescara and manufactured by Societe Industrielle Generale de Mecanique Appliquee, is now actually installed in a powerplant, in a locomotive, and in a number of French Naval Vessels. In fact, he thought the **most important progress** in application of free piston engines to marine use has been made in France. The French Navy is installing Sigma Model GS-34 powerplants in fifteen minesweepers and two frigates. This model also can be applied to pipe lines and auxiliary vessels where a heavy duty, reliable, highly efficient unit is desirable.

An interesting investigation being conducted by Sigma—the application of the free piston engine to truck drive, was mentioned by McMullen. In addition to lowering the cost of maintenance and operation of the engine itself, a free piston truck drive should permit a **greater pay load** and provide a better transmission system.

Feb. 12-Mar. 19

THE EDUCATIONAL LECTURE SERIES on "Engineering Know-How in Engine Design" initiated by the Milwaukee Section in the '52–'53 Section year has furnished a real **service to engineers** in the area. The first series was so popular that a second one was operated this Section year on other **facets of engine design.**

Section Chairman Spexarth and Lecture Chairman Esty attribute the success of this effort to one big factor: This kind of practical design information, dished up by leading engine designers, is not available in text books or other published material.

San Antonio of Texas Gulf Coast

Field Editor
Leil Zar
Mar. 22

TO SUPPRESS SPARK-PLUG FOULING and preignition, the Ethyl Research Laboratories have found a gasoline additive that offers more promise than any other line of control, Idan E. Flaa said. He is chief automotive engineer of the Southern sales region of Ethyl Corp.

Flaa said that the laboratories tested many chemical compounds but just one, which they've designated "Ignition Control Compound," met all the requirements that were set. He said it offers these advantages:

1. **Carbonaceous deposits** in the engine cylinders

From Section Cameras

Detroit (Jan. 25)

"Photography in Automotive Engineering" was the subject of the panel shown above at Detroit Section's Junior Activity Meeting. Left to right are: William McCarthy, research engineer, Ford; Ellis Rifkin, research supervisor, Ethyl Corp.; Frank Thomas of Chrysler; Michael Turkish, chief engineer, coil spring department, Spring Division, Eaton Mfg. Co.; Louis Lundstrom, assistant director of GMC's proving grounds at Milford, Mich.; and Worth Percival, research engineer, Research Laboratories Division.

Northwest (Mar. 11)

Posed for photographer are: (left to right) Martin Headman, project engineer for Western Gear Works, Seattle; C. F. Blakely, flight test engineer, Boeing Airplane Co., and Section vice-chairman of Aircraft Activity; Speaker John V. Long, director of research, Solar Aircraft Co., San Diego; Section Chairman R. C. Norrie, chief engineer, Kenworth Motor Truck Corp., Seattle; and Vice-Chairman C. E. Johnston, head of the automotive trades department, Edison Technical School, Seattle. Speaker Long's paper, was, "Ceramic Coatings for Exhaust Systems."

are prevented from becoming incandescent and causing preignition.

2. Spark-plug deposits are **converted into nonconductors** of electricity and thereby fouling is eliminated under normal passenger-car operation.
3. Because preignition is suppressed, octane requirement is lowered to that needed to suppress ordinary knock.

Alberta

Mar. 26

AN OFFICIAL VISIT was made by E. W. Rentz, manager of the Western Branch office, to the new Alberta Group. Rentz gave the Group a little back history, described SAE's organization, what members can get from the Society and what they can do for it.

He went along with the Group members on a tour of The Institute of Technology and Art at the request of Secretary Wesley Moore and Treasurer Fred Forster. Forster is an instructor at the Institute.

South Bend Division of Chicago

Field Editor
D. W. Miller
Mar. 15

IN THE 1954 MERCURY ENGINE useful horsepower has been increased over last year's model from 70–80%, and a reduction in friction horsepower from 30–18% at wide-open throttle. That was what Frank A. Veraldi told Section members. He is Lincoln and Mercury engine engineer for Ford.

He said that this change results in less heat transfer to the water coolant, reducing radiator size and weight, and improving efficiency.

Veraldi also mentioned a four-barrel carburetor with a new "balanced breathing" intake manifold, a new spark advance system, the use of five main bearings instead of three, and many other new features.

Central Illinois

Field Editor
W. J. Lux
Mar. 22

TODAY'S ENGINEERING STUDENTS are keenly aware of the task facing engineers, and they are eager to give their best service. This was agreed by a panel of engineers at the March meeting.

The panel thought that preparing for a successful engineering career requires certain personal qualities including **individual initiative**—rather than just college education and technical training. Another point the engineers agreed upon was that the engineer's role in **modern economy** is becoming more and more prominent as our lives become increasingly complicated by technical advances.

Panel members were: Technical Chairman L. J. Fletcher, vice-president of Caterpillar Tractor Co.; R. T. Milner, Northern Regional Research Laboratory; W. N. Foster, sales department, Caterpillar; R. E. Gibbs of Bradley University; Jack Cranshaw, consultant engineer; and Dr. Ernst Spannhake of Le Tourneau-Westinghouse.

Questions were asked by the following student members: (University of Illinois) John B. Witt, William E. Evans, Walter Glitzenstein; (Bradley University) Carl A. Larson, Edward Stear, and Chester Strantz.

Salt Lake

Field Editor
W. P. Barnes
Mar. 15

THERE IS AN URGENT NEED FOR AGREEMENT among the States to standardize trailer dimensions and tire loadings. That was the opinion of Lloyd Mallet at the March meeting.

Mallet, assistant chief engineer of Kenworth, also believes titanium "might well find its way into the **truck-trailer market**" because of high strength and low-weight characteristics. As for air springs, he doesn't think they have reached the stage of development where they can compete in general use with leaf or torsion bar springs.

Northwest

Field Editor
W. M. Brown
Mar. 11

A CERAMIC COATING THAT RESISTS RED FUMING NITRIC ACID at 90 deg F for over three months—without losing its surface gloss, has been developed by Solar Aircraft Co. That was what John V. Long, director of research for Solar, told Section members.

Long also reported that Solar has come up with coatings that can **resist molten metal**, gall, and abrasion. Before a ceramic coating, thermocouple wells in Kirksite die pots lasted only 2 or 3 days due to the attack of molten metal. . . . After using it, however, they lasted a whopping-big 30 to 60 days, according to Long. Still another coating, **an anti-gall ceramic**, he said, resulted in a friction load of less than half that allowable under a working condition of 750 deg F at 235 psi.

Metropolitan

Field Editor
L. Peat
Mar. 11

BY 1960 WE WILL HAVE TRANSPORTS CRUISING AT 600 MPH. This was the prediction of SAE's president, William Littlewood at Met Section's March Meeting.

The president thought this was entirely consistent with past rates of development, and said that it appears "quite possible with known techniques." However, he said, it is not quite so apparent exactly what propulsion devices we will use to achieve such speeds. ". . . if we are to accept the assurances of

Western Michigan (**Feb. 16**)

From Section Cameras

Taking the speaker's stand is E. F. Lewis, central regional sales manager for GMC's Truck and Coach Division. His paper was, "Development, Application and Maintenance of Motor Coaches."

Twin City (**Mar. 10**)

Glancing at film that Section members saw on development of a ramjet target-drone combination are: Prof. Newman A. Hall, chairman of Twin City Section; Speaker J. W. Braithwaite, assistant chief aerodynamicist Marquardt Aircraft Co.; and Daniel L. Mellen, chairman of the IAS Twin City Section. The occasion was a joint-meeting of the SAE and IAS Sections.

the respective enthusiasts, it can *easily* be done with jets, it can *reasonably* be done with by-pass type engines, or it can *possibly* be done with the use of turboprops."

Littlewood also said he saw much **more business and activity** long into the future. "Since 1930 air transportation in America has grown more than 25% a year on the average. The curve is still continuing upward. . . ."

A "crying need" for future transports, according to the president, is a better way of loading and handling baggage and cargo. Because **more passengers** will be transported, Littlewood believes there will be a need for two main loading doors, with door-type emergency and service exits available fore and aft on the opposite side of the fuselage.

Northern California

Field Editor
R. E. Van Sickle
Mar. 24

STUDENTS PRESENTED PAPERS TO MEMBERS at the Section's Annual Student Meeting at the University of California. The papers were based on experiments the students had conducted. Judges awarded Richard Canzoneri of Cal-Poly first place for his presentation on the frictional torque of **grease seals.** He told how the initial friction from a spring loaded Buna rubber grease seal can exert ¼ or more equivalent horsepower frictional torque. This frictional torque falls off to a fraction of this value as the seal wears.

The development of an inexpensive apparatus for determining **vapor pressures of aircraft fuels** from −100 deg F to +140 deg F was disclosed by James Dutzi of the University of California. He indicated the need for such apparatus in order to evaluate the vapor pressure characteristics of aircraft fuels over the range of temperatures encountered by modern aircraft.

Results of engine tests utilizing a lubricating oil additive for the purpose of **reducing engine friction,** was discussed by Richard Kern of the University of Santa Clara. He disclosed that engine friction was reduced by the same amount that would have been obtained using a lubricant equivalent in viscosity to the blend of the base lubricant plus the additive.

The meeting followed a tour of engineering facilities at the University of California. Technical chairman of the meeting was Professor E. S. Starkman of the University of California.

Texas Gulf Coast

Field Editor
W. B. Tilden
Mar. 12

WHEN TEXAS LOAD WEIGHT REGULATIONS WERE CHANGED in 1951 from 48,000 lb to 58,420 lb gross combined weight, the Humble Oil & Refining Co. decided to take advantage of the new regulations. The first move was to purchase forty 6000-gal transport-trailers, but when these were used with the old standard truck-tractor, powered with a 386 cu in. displacement engine, performance was so poor, it was considered unsatisfactory.

D. B. McFadden and F. M. Jobes of Ethyl Corp. told members that with the use of SAE SP-82 method of **computing performance** of tractors, they were able to determine that they would need an additional 14.2 hp for transports and 22 hp for van trailers at 45 mph to take advantage of the additional 10,000 lb load allowed.

Also with the use of **the SAE SP-82 method** they were able to study the effect on performance and operation of five-speed transmissions used with single-speed and two-speed rear axles, by means of observations of gearshift "gaps" and "overlaps."

McFadden believes that his experience using SAE SP-82 to compute the predicted performance of tractors for transport and van service has indicated the method is both satisfactory and beneficial, and is an aid in making studies to guide in a better selection of tractors.

Rochester Division of Buffalo

Field Editor
D. I. Hall
Mar. 18

NEARLY 600,000 DESIGN MAN HOURS were spent on the development of the new Ford V-8 engine. That's what K. L. Vogt, assistant supervisor of the Ford Engine Section told members in presenting Robert Stevenson's paper, "The New Ford V-8 Engine." Stevenson is chief engine engineer for Ford.

Some other statistics brought out were:

1. In developing this new engine, more than 400 experimental engines had to be built
2. These engines were tested on dynamometers for a total of more than 160,000 hours
3. Were in vehicles which accumulated more than 2½ million miles

Dayton

Field Editor
P. J. Long
Mar. 18

WITH AN OPERATING TIME OF 30,000 HR, a gas turbine driving a 3500-kw generator has been in service over four years. This was brought out by B. G. Hatch at the Section's March meeting. Hatch is engineer with the Turbine Division of GE.

Where 33 cu ft of space are required per kw for steam turbine powerplants, only 7 cu ft per kw are needed for those powered by gas turbines, according to Hatch.

Some other interesting facts pointed out were: 85 commercial gas turbines have been produced and shipped to date—65 of these units are in operation today; 10 **locomotives powered by gas turbines** have been built and are in use today, and the combined service of these locomotives totals over 1,400,000

From Section Cameras

Mid-Michigan (Mar. 29)

Certificates of appreciation were awarded to Charles Standard (left) for committee work on involute splines (Formerly gear engineer at Buick's Motor Division, he is now retired), and C. G. Davey, executive engineer at GMC's AC Spark Plug Division, for service on the Tube-Pipe, Hose and Lubrication Fittings Committee. Chairman E. H. Holtzkemper (center) presented certificates which were awarded by SAE's Technical Board.

At Buick's new V-8 engine plant are: (left to right) C. G. Davey, GMC's AC Spark Plug Division; E. T. Ragsdale, Buick general manufacturing manager; C. G. McDougall, Grandsen-Hall & Co.; David Hadden, Chevrolet's Flint Mfg. Division; V. E. Hense, Buick chief metallurgical engineer; E. H. Holtzkemper, Buick engineer and Section chairman; Harold Sieggreen, chief engineer of the Central Foundry Division; E. W. Otto, F. J. Boutell Driveaway Co.; and V. P. Mathews, Buick's chief engineer.

South Bend Division, Chicago Section (Mar. 15)

Enjoying dinner-meeting are: (left to right) Charles Cooney, experimental engineer, Studebaker; Division Publicity Chairman Dorr W. Miller; Chicago Section Secretary M. P. DeBlumenthal; Speaker F. A. Veraldi, Ford's Lincoln and Mercury engine engineer; T. A. Scherger, chief powerplant engineer, Studebaker; John Nemeth, engineer assistant, Studebaker; and Ralph Handy, experimental engineer, Studebaker.

"Engineering Know-How . . ."

From Section Cameras

Milwaukee (Feb. 12-Mar. 19)

For the second straight year, now, the Milwaukee Section's educational lecture series on "Engineering Know-How in Engine Design" has been drawing standing-room-only crowds. At right is just a part of the jam-packed audience that attended one of the sessions in the current series.

Above are the headliners at the fourth lecture. They are (left to right): Education Lecture Chairman F. B. Esty; Sheldon Pollon, Power Products Corp., who talked on "Four-Cycle Engine Design Considerations"; L. J. Lechtenberg, Briggs and Stratton Corp., who spoke on "Two-Cycle Engine Design Considerations"; and Section Chairman C. L. Spexarth.

miles. Hatch also told members that gas turbines have been operated on a number of fuels including natural gas, propane, and fuel oil.

Twin City

Field Editor
S. H. Knight
Mar. 18

ONLY THE RAMJET shows an increase in thrust coefficient with increasing Mach number according to J. W. Braithwaite, Marquardt Aircraft Co.'s chief aerodynamicist.

Braithwaite told the section the best **thermal efficiency** in ramjet engines occurs in supersonic flights over Mach number 1.5. To be competitive with other **air-breathing engines,** it requires a compression ratio between 5 and 15, which corresponds approximately to a Mach number range of 1.5 to 4.0.

He said, too, that at high speeds, fuel consumption is good, thrust per pound of dry engine weight is good and—cost per pound when produced in large quantities, is less than any other powerplant.

The ramjet must be brought up to flight speed by some other powerplant, however, since its air compression is derived entirely from its forward motion through the air and it cannot develop thrust while at rest.

Wichita

Field Editor
W. E. Shelor

MORE ABOUT THAT BABY-SITTER . . . Last month's Journal carried the report that Edwin G. Bracher, speaker at the Section's February meeting, had taken his infant daughter from Stockholm, Sweden, to a baby-sitter in New York—returning to Stockholm in less than 60 hours. Some people have wanted to know why anyone would travel that distance for a sitter. The incident happened to be the result of an epidemic that prevented the services of a trained nurse Bracher had hired so that he and his wife could accompany his parents on a two-week tour through Europe.

Mar. 17

Local Caterpillar representatives were introduced and R. J. Pitzen, sales development engineer for Caterpillar, gave a talk on **engineering development** covering diesel engines, earthmoving, and other heavy-duty equipment. A film was also shown.

Pittsburgh

Field Editor
O. B. Rosstead, Jr.
Mar. 23

ANYTHING FROM NATURAL GAS TO HEAVY FUEL OIL can be used for the simple gas turbine. That was what Max Roensch, director of laboratory tests at the Chevrolet Motor Division, GMC, told members.

He said that the turbine has no cetane or octane requirements and when compounded with a gasoline engine (as the Wright 3350 Turbo-Compound aircraft engine), the overall **fuel consumption is reduced** to 0.4 lb per hp-hr.

Roensch also told members that in the comparison of various types of powerplants for automotive use, thermal efficiency was of vital importance and for the present, at least, the gas turbine was too inefficient under low load conditions to be used successfully.

SAE Past-President R. J. S. Pigott pointed out that Ricardo and Napier have made compound engines with fuel **consumptions as low as 0.3–0.35** lb per hp-hr.

In regard to the simple gas turbine, he said that the main problem was to be able to use engine temperatures of 3000 F instead of the 1500–1600 F now being attained. The limiting factor, he continued, is the lack of metals capable of withstanding these higher temperatures.

St. Louis

Field Editor
A. W. Zub
Mar. 9

TWO PLANES COLLIDING OVER NEW YORK would cost $15,000,000. A single plane accident would cost $5,000,000, according to Jerome Lederer. He is director of the Flight Safety Foundation, Inc., New York.

In his paper, "Progress and Problems in Air Safety," Lederer mentioned advances being made **to protect passengers:** seats that are prepared for extreme forces in any direction, escape hatches that are fool proof, and interiors that eliminate **congestion in aisles.** A film, "Crash Fires," forcefully illustrated the progress in eliminating all sources of gasoline fires.

The meeting was the Section's annual "Students' Night" and members of the Parks College Student Branch conducted the program.

Cleveland

Field Editor
W. B. Fiske
Mar. 22

THE CORVETTE PLASTIC BODY WEIGHS 411 LB. Besides its light weight, the body will not rust, will not crumple in collision, will take a paint finish, and is rather free from drumming noise. That's what the director of the research and development section of GMC's Chevrolet Motor Division told members. He is Maurice Olley.

The occasion was Cleveland Section's Student Meeting. With Olley was John Coffin who put on a demonstration of the process used in making the plastic body panels.

Olley said that these panels have approximately the same stiffness as steel panels that weigh twice as much. They are laminated constructions of glass fibers impregnated and bonded by a clear plastic.

He mentioned that the control lever for Corvette's automatic transmission has been placed beneath the driver's right hand, alongside the transmission. When this lever is on the steering column, it obscures the instruments.

TECHNICAL COMMITTEE *Progress*

You Can Better Fatigue Life, But Never Predict It Exactly

Prof. Thomas J. Dolan, University of Illinois

Excerpts from talk "The Nature of Fatigue Weakness in Metals" before Division XX—Shot Peening of the SAE Iron and Steel Technical Committee, Hershey, Pa., Oct. 1, 1954.

CONSIDERATION of the many variables and uncertainties that occur in practical service conditions makes it impossible to predict a precise fatigue life for a member such as an airplane wing, a turbine blade, or a gun tube.

However nearly all chronic cases of fatigue trouble are traceable to localized peak stresses resulting from conditions recognizable in advance. Small decreases in these maximum stresses are invariably accompanied by a large improvement in fatigue life.

Thus even though exact procedures of a mathematical nature for proportioning parts are not available, the elimination of severe stress raisers and care in processing operations will do much to prolong fatigue life and give satisfactory service.

Material is Nonuniform

Because of the heterogeneity of the polycrystalline metal, the response of a part to an external load will necessarily be that of a model built up statistically of elements that have a range of values in size and whose strength varies as a function of size and orientation of the elements.

As these disruptions develop, they accelerate by jumping and forming together and grouping until a microscopic crack is formed. Thus the mechanism includes an accumulation of chance effects in nucleation and growth and is quite different from that encountered under a single static load. The microscopic readjustments that initiate in weaker crystals are multiplied in their severity by the repetitions of loading until fractures are developed at relatively low nominal stresses. Hence the metal appears to be weak as compared with the usual concepts of static strength.

Flaws Weaken Structure

The weakness of metals under repeated loading is not surprising when consideration is given to the presence of the following inhomogeneities that lower the resistance to mechanical stressing:

SAE Thanked by Government Agency

SAE recently was awarded the above "certificate of cooperation" by the Foreign Operations Administration. Basis for the award was SAE's informal cooperation for arranging consultation between delegations of foreign technicians and American engineers.

In June of 1951, SAE arranged a meeting between a group from the United Kingdom and metallurgists and engineers in Detroit on conservation of scarce materials. The Society also set up a similar meeting last October for a German group studying non-cutting metal forming.


FOREIGN OPERATIONS ADMINISTRATION

UNITED STATES OF AMERICA

CERTIFICATE OF COOPERATION

awarded to

Society of Automotive Engineers, Inc.

for furnishing technical assistance to the peoples of friendly countries cooperating to maintain individual liberty, free institutions and peace.

Harold E. Stassen
Director of Foreign Operations

Cornish Heads New A-6 Subcommittee

HEAD OF A NEW WING under SAE Committee A-6, Aircraft Hydraulic and Pneumatic Equipment, is Harry E. Cornish of Douglas Aircraft. He has accepted the chairmanship of the new subcommittee A-6C, Hydraulic Pumps, Motors, and Air Compressors. A-6C will carry on work formerly done by Committee A-1 on Aircraft Hydraulic Pumps.

1. Random agglomeration of anisotropic crystals of wide variation in shape and size.

2. Mixed phases of different elastic characteristics such as inclusions differing physically from the matrix and crystal imperfections in lattice or atomic pattern.

3. Discontinuities and segregation streaks.

4. Textural stresses on a micro scale.

Many factors influence the fatigue life of a metal part. The rate at which damage is accumulated either in initiating or in propagating visible cracks is, in general, influenced by the mechanical strength properties of the fabricated member. These include not only the chemical composition and metallurgical structure, but also the influence of surface finish, plastic deformations in processing, and shape and size factors inherent in the design of a member. Other properties are the state and range of stresses that must be resisted in the most critically stressed localized zones of the member. Also important are environmental conditions such as corrosive atmosphere, erosion, or elevated temperatures.

Cracks Start at Surface

In general fatigue cracks initiate in the exposed surface of a metal part, unless unusual circumstances or processing treatments (such as nitriding) develop surface layers of substantially higher strength than the inner zones of metal. Apparently surface crystalline grains are inherently weaker than interior grains that are confined by bonds with adjoining grains.

As long as the metal is sound and free from inherent defects, selection of material, within wide limits, is not as important in achieving satisfactory fatigue life as is care in design, fabrication, and maintenance. For members containing severe stress raisers it is sometimes found that only minor improvements can be expected by changing to a "higher-strength" metal except under unique conditions such as those involved in operation at extremely high temperatures. Quite often the elimination of harmful conditions is found to be a more economical and effective means of improving fatigue strength. Here are five ways to do it:

1. Eliminate sharp recesses and severe stress raisers by use of generous fillets with general streamlining of the part to provide smooth gradual transitions of stress.

2. Avoid sharp surface tears from rough machining, punching, stamping, and shearing.

3. Prevent surface decarburization during processing or heat-treatment.

4. Control (or afford protection against) corrosion, erosion, or chemical attack in service.

5. Alter design to eliminate press fits, dovetails, or other mating parts that in transferring the load develop a microscopic chafing action that seriously reduces fatigue strength.

One thing to keep in mind is that at the surface, there is not the same degree of bonding of submicroscopic units that there is below. That is why slips, separations, and failures are most likely to start at the surface. If we can locally bond the surface crystals, the tendency for slip to start is lessened. That is what shot peening

does. It ties together the surface particles and thereby improves strength.

Problem Is Now More Acute

Fatigue problems have become more intense as speeds of equipment and driving engines have increased and the life of mobile conveyances has been extended.

Until the development of high-speed transportation equipment such as the steam locomotive and the automobile, engineers were little concerned with fatigue failures. But as a logical step in the efficient design of all forms of mobile equipment, it became necessary to reduce the size and weight of all elements—such as gears, shafts, and connecting rods. This tended to increase the peak stresses.

In the early days of the steam engine, the speeds were so slow and parts so cumbersome that the occurrence of an occasional failure was remedied by replacing with one made bigger and heavier. Thus design for fatigue resistance was not a particularly acute problem.

Turbines Suffer Fatigue

In contrast to this, fatigue strength is of paramount importance to modern equipment running at high speeds and with elements such as turbine blades vibrating at thousands of cycles per second, particularly where emphasis is being placed on a high strength/weight ratio.

1954 SAE Handbook To Be Mailed in May

THE 1954 SAE Handbook will be ready for mailing later this month.

It contains current SAE Standards, SAE Recommended Practices, and SAE General Information Reports approved by the Technical Board up to and including new and revised material approved at its January meeting.

Twenty of the documents are entirely new, and many others have been revised from the 1953 edition. Among the new material are sections on Preferred Thicknesses for Uncoated Thin Flat Metals, Average Vehicle Dimensions for Use in Designing Docking Facilities for Motor Vehicles, and Industrial (Track-Type) Tractor Nomenclature. Revisions have been made in Sealed-Beam Headlamp Units for Motor Vehicles; Tube, Pipe, Hose, and Lubrication Fittings; and in Hardenability Bands for H Steels—among others.

Members Get One Free

Each SAE member is entitled to one copy of the Handbook free. This copy will be mailed this month to each member who indicated on his dues bill last fall that he wanted the book. Other members may have a copy free by asking for it. Members desiring more than one copy may obtain additional copies at the special rate of $10. Price to nonmembers is $20.

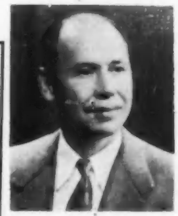
Reprints of the iron and steel section of the 1954 SAE Handbook will be available to members at $3 and to nonmembers at $6. Reprints of the lighting section will be available at 75¢ to members and $1.50 to nonmembers.

About SAE Members—continued from page 86

RICHARD V. DAVIS, formerly sales engineer for General Electric in San Diego, is now aircraft gas turbine specialist for GE at Los Angeles.

WILLIAM W. McCLINTOCK is now powerplant engineering supervisor for Pan American World Airways at the Miami International Airport Florida. He was previously powerplant service engineer for Pan American at New York International Airport. McClintock has been vice-chairman of the Air Transport Activity for the Metropolitan Section.

EDWARD H. FARMER has been appointed head of E. W. Bliss Co.'s new Pacific Coast manufacturing plant at San Jose, Calif. Farmer was formerly vice-president, manufacturing, for Pacific Airmotive Corp., Burbank.


Farmer


Duncan

ROBERT F. DUNCAN has been made manager of the Package Products Division of Calumet Refining Co., in Chicago. He continues in the capacity of secretary and treasurer and a member of the board of directors.

SAM DABICH is now employed as a project engineer with the products development laboratory of Borg-Warner Corp. Dabich was project engineer for the Detroit Transmission Division of GMC.


Dabich


Baker

T. N. BAKER, former sales engineer for the Allison Divison of GMC in San Diego, is now general sales manager of Consolidated Tool & Products Co., Los Angeles.


Schroeder

ROBERT A. SCHROEDER has joined the Homelite Corp., Port Chester, N. Y., as quality control manager. Schroeder was production planning manager for F. L. Jacobs Co., auto hardware manufacturer, Detroit.

About SAE Members—continued

C. FAYETTE TAYLOR, professor of automotive engineering and director of the Sloan Laboratories at Massachusetts Institute of Technology, has announced a course to be given next summer at MIT for engineers in industry and college teachers. Since the empirical methods in all branches of mechanical engineering are being replaced by "new techniques of analysis, correlation, and carefully planned and controlled experimental procedure," the purpose of the Internal-Combustion Engines Program is to discuss the application of such methods in the field of power machinery. The course will be a two-week special summer program from June 15 through June 25.

Taylor

Wetzel

GUY F. WETZEL, technical editor of "Automotive Digest Magazine," Park Ridge, Ill., has written a new book "Automotive Diagnosis and Tune Up." It analyzes the systems making up the powerplant, giving the "anatomy" of each, and its correct functioning. Various kinds of trouble that may be experienced in each of the systems, recognizable by deviations from normal functioning, are also given.

Analyses of engine noises, comparison of firing orders, causes of poor engine performance, the turn signal circuit, and operation of the four-barrel carburetor are also included. Containing 536 pages, with 600 illustrations, in a library quality binding, the book is published by Master Technical Press, Park Ridge, Ill., for $6.00, postpaid.

KING A. KOCH has become sales manager for the Engineering Supply Co., Dallas. He was previously Southwest regional sales manager for Union Asbestos & Rubber Co.

ROBERT S. KORF, formerly racing director for Kiekhaefer Aeromarine Motors Research Lab in Oshkosh, Wis., is now research and development engineer for the Department of the Army, Transportation Corps, Liaison Office, at Wright-Patterson Air Force Base, Ohio.

THEODORE GENSEL, formerly senior engineer, flight test, Chase Aircraft, West Trenton, N. J., is senior aero engineer for Stroukoff Aircraft Corp., West Trenton. He was student treasurer at SAE's Branch at Northrop Aeronautical Institute in 1948.

ADOLPH J. JEUDE is a mechanical engineer for the Pandjiris Weldment Co., St. Louis, Mo. He was assistant chief engineer for Nordberg Mfg. Co.'s Busch-Sulzer Division, St. Louis. He was 1948-49 Chairman of the St. Louis Section.

Powerplants Need Better Thermodynamics

Based on paper by

C. G. A. ROSEN

Caterpillar Tractor Co.

AS a rule, in all modern powerplant projects too much effort has been spent on gadgetry and in adding extraneous accessories which have no essential value in improving thermodynamic performance. Gadgets and accessories raise friction horsepower, and this contributes ultimately to a reduction in economy. Powerplant development must be concerned with improving cycle efficiency and proper allocation of temperature levels in relation to the capacity of parts to furnish adequate heat transfer.

In general, powerplant development should be directed along four channels:

1. Highest horsepower per pound of material as exemplified by the four-cycle turbosupercharged engine.
2. Highest horsepower per cubic foot of space as in the two-cycle loop-scavenged design.
3. Highest horsepower per pound of total material plus fuel as shown in the free piston compressor plus gas turbine combination.
4. Maximum portability per horsepower as expressed in gas turbine developments. (Paper "Some New Types of Vehicle Power Plants" was presented at SAE Milwaukee Section, Milwaukee, Dec. 4, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

New Flat Polishing Techniques Cut Costs

Based on paper by

ADAM ZIMMERMAN

Acme Mfg. Co.

DEVELOPMENT of the "pinch-roll" or through feed type of machine for the flat polishing of sheet metal has made the cost of prepolishing hot rolled steel less than the difference in price between hot rolled and cold rolled steel.

Flat polishing leaves a uniform and finer finish on base metals. It insures good plating, better paint adhesion, and less die friction. A test on helium-arc welded parts revealed that flat polishing reduced the number of blow holes. Where holding to size is important, the "pinch-roll" type of equipment can grind to tolerances of ±0.001 in.

In this paper the author also describes the construction of a "pinch-

roll" machine and details the principles of operation with illustrations. (Paper "Flat Polishing—An Outline of New Techniques in Sheet Metal Polishing" was presented at SAE Detroit Section, Feb. 1, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Bonding Ourselves For Roads Has Limits

Based on paper by

WILLIAM A. BUGGE

Washington State Highway Commission

IT is natural for people to defer the day of reckoning. In the highway field we are tempted to do this by issuing bonds to finance highway improvements rather than to take the money out of our current income to do the job we want to do. But it would be a mistake to suppose that we can go on indefinitely bonding ourselves to obtain revenue. The more bonds we sell, the more of our future construction revenues we commit to paying back the money, and the less we have for improvement. We ought to stop, look, and listen every time we hear a proposal to sell bonds to finance future highway improvements. (Paper "Washington's Highways and Their Future" was presented at SAE Northwest Section, Seattle, Nov. 6, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Sky Is No Limit For Aircraft Industry

Based on paper by

J. M. PEDERSON

General Electric Co.

THE next so-called barrier to be passed is the thermal barrier, the problem of high temperatures encountered at very high flight speeds. The aircraft industry is attacking this problem vigorously through development of improved materials, methods of construction, and cooling systems.

We will overcome this barrier as we have overcome others. If we must have flight at twice or three times the speed of sound to maintain air supremacy, we will have it. If flight altitudes of 75,000 to 100,000 feet are necessary, we will have them. If we cannot get the performance we want from turbojets, we will go to ramjets,

rockets, or other powerplants. For the aircraft industry, the sky is no limit. (Paper "Aircraft Gas Turbines" was presented at SAE Metropolitan Section, New York, Nov. 12, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Stresses, Deflections In Ring Gear Analyzed

Based on paper by

Joseph Marin
The Pennsylvania State College

and R. H. Shenk
Consultant

AN analytical procedure using the strain energy method makes it possible to find the maximum stress and radial deflection in the ring gear of a planetary gear system.

It is believed that this procedure is considerably more accurate than other methods that are sometimes used for the determination of stresses and deflections in ring gears.

The reason for making an accurate analysis of the stresses and deflection of the ring gear is that it is essential to provide the most flexible gear which has at the same time adequate strength. Flexibility in the gear is desired in order to make possible a uniform load distribution between the planet gears and thereby provide maximum power capacity for the unit.

The analysis also provides a general solution to the problem of a ring subjected to radial and tangential forces and couples acting at various points on the circumference of the ring. (Paper "Stresses and Deflections in Planetary Ring Gears" was presented by title at SAE Annual Meeting, Detroit, Jan. 13, 1954. Paper contains calculational procedure as well as derivation. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members; 60¢ to nonmembers.)

Service Tells Facts On New Diesel's Economy

Based on paper by

W. J. PELIZZONI
International Plainfield Motor Co.

OF the two groups of experimental Thermodyne diesels subjected to field trials prior to start of production, some have been returned for examination. This has permitted compilation

of cylinder linear wear for nine of these engines.

Three engines removed from buses show a wear rate varying from 0 to 0.007 in. per 100,000 miles. The engine with the greatest wear rate is the one with the least mileage as might be expected because initial wear on any liner and ring combination will be greater than average wear after prolonged use. The six engines from trucks prove this point beyond doubt. The wear rates at mileages well over 100,000 for five of the six engines are no greater than 0.004 in. per 100,000 miles.

Cylinder liner durability is reflected in low piston ring end gap increases and general excellent component life. And for this may be credited: (1) cleaner and finer combustion with less contamination of the lube oil; (2) better distribution of heat (no hot spots); and (3) less heat because of improved thermal efficiency. Oil consumption was so low that the engines were still averaging over 500 mpq at the time they were removed. Fuel consumption of those engines used in heavy-duty high-speed over-the-highway trucks averaged well over 200 ton-miles per gal. (Paper "How Mack Thermodyne Diesels Better Sustained Economy" was presented at SAE Metropolitan Section, New York, Nov. 18, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Know Your Engine To Prolong Its Life

Based on paper by

KENNETH L. HULSING
General Motors Corp.

THE diesel engine builder and the end product manufacturer have a responsibility to turn out an enduring product, but it is always the operator who gets the final chance to make his engine live.

An understanding and wise use of engine horsepower and speed will increase engine life. A knowledge of the inter-dependent effects of fuel and lube oil qualities will allow the operator to choose the best combination for his operation whether it be sustained or intermittent, light or heavy loads, in cold or normal temperatures. Altitude need not cause shortened engine life if the operator will adjust his fuel quality and quantity in accord with the engine's ability to burn it under the prevailing atmospheric conditions and elevation. Most conditions causing abnormal bearing, ring, and liner wear are under the control of the operator. Finally, to extend engine life and improve performance, personnel

must be trained to maintain specific equipment. (Paper "Factors Influencing Operating Performance and Life of Diesel Engines" was presented at SAE St. Louis Section, St. Louis, Dec. 8, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Unique Tariff Helped Canadian Auto Industry

Based on paper by

J. C. ARMER
Dominion Forge & Stamping Co., Ltd.

A MAJOR factor in the development of the Canadian automotive industry has been a basic principle, unique in protective tariff treatment, adopted by the Government. This principle was that (1) no attempt should be made to protect by tariffs those automotive parts which are definitely uneconomical to make in Canada because of quantity disparities, high tooling costs with probable frequent changes in design, special purpose machinery, materials not made in Canada, or other good reasons, and (2) parts should be made duty free to those automobile manufacturers having a stated percentage of Empire content in the cost of their factory operations.

Tariff-free parts have helped materially to reduce costs, while the "Empire content" and "made in Canada" requirements were the far-sighted provisions which have fostered economically sound manufacturing. (Paper "Canadian Government Fiscal Policy on Automotive Tariffs" was presented at SAE Toronto Production Forum, Oct. 29, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Low Pressure Jet Pumps Analyzed

Based on paper by

HOWARD R. MOOS
Caterpillar Tractor Co.

JET pumps, ejectors, or eductors as they are variously called, are widely used for industrial applications where their simplicity, lack of moving parts, and low initial cost make them attractive. In spite of their simple appearance the detailed analysis of these devices is quite involved. However, many experimental and analytical studies of them have been made.

In this paper, the author presents an approximate analysis of venturi-type low pressure air ejectors, extended to shapes other than a venturi, and shows

the predictions of the analysis to be in reasonably good agreement with experimental results. (Paper "Analytical and Experimental Study of Low Pressure Air Ejector Pumps" was presented at SAE Central Illinois Section, Peoria, Dec. 14, 1953. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

Fatigue Problem Needs Basic Research

Based on paper by

H. T. JENSEN

Sikorsky Aircraft

THE method of attack for solving the the helicopter fatigue problem should be directed at increasing knowledge of the basic parameters—fatigue strength, loads and stresses and their occurrence, and methods of analysis. There seems to be nothing unique about the strength problem as far as the helicopter is concerned, but there are many unique factors for the aircraft industry as a whole where special materials and fabricating methods apply. Basic research is needed to allow better approaches to analytical strength determination. There is urgent need for standardization of methods of presenting fatigue data.

Attention should be directed to the wealth of unsifted material data that is available. Sikorsky has been reducing available data by making the stress or load ordinate dimensionless by dividing by the indicated endurance limit. The attempt is to establish representative slopes for the failure point of the S/N curve. While the first logical approach to the strength problem is materials research, the aircraft designer is more interested in structures' fatigue strength problems. The various factors influencing structural strength will have to be isolated so that such parameters as size, shape, finish, and fit can be applied to the basic materials properties to evaluate the strength of the structure.

The research required to make structural fatigue strength analysis a possibility will not be completed in the next few years. In the meantime, the best solution to strength determination will be full-scale testing.

The load and stress problem, as opposed to the strength problem, belongs particularly to the helicopter. It is the fatigue life parameter that emphasizes the basic problem. Here we look to research for improvements in existing methods or discovery of new methods of stress and load analysis with the hope that some day the strain gage will not be tied so intimately with helicopter development. (Paper "The Problem of Relating Accumulated Service Fatigue Damage to Remaining Life" was presented at SAE Annual

Meeting, Detroit, Jan. 14, 1954. It is available in full in multilithographed form from SAE Special Publications Department. Price: 35¢ to members, 60¢ to nonmembers).

New Ways to Measure Engine Gas Temperature

Based on papers by

G. H. MILLAR
Ford Motor Co.

O. A. UYEHARA
and
P. S. MYERS
University of Wisconsin

S. K. CHEN
International Harvester Co.

N. J. BECK
Douglas Aircraft Co.

Complete papers will appear in 1954 SAE Transactions.

TWO characteristics describe the radiation from a flame for a given wavelength range, i.e., its tempreature and its emissivity. Since absorptivity equals emissivity, measurements of absorptivity and radiation intensity from a flame in a narrow wave-length range permits the determination of the temperature of that portion of the flame in the light path.

In the arrangement used for this work "chopped" light from a molten zirconium-arc lamp passed through the combustion chamber onto the entrance slit of a spectrograph. This varying radiation-intensity was measured by a photomultiplier located at the sodium wave-length. The decrease in intensity of the "chopped" light was a measure of the absorptivity of the flame. When the light was interrupted by the chopper, the same photomultiplier measured the radiation from the flame alone. Combination of the two readings enabled the temperature of the flame to be determined.

Another technique involved the use of a trace of iodine gas to indicate temperatures. An optical-electronic system measures the change in color of the iodine from which measurements the temperature of the iodine and by inference the temperature of the gases is determined. (Papers "Practical Application of Engine Flame Temperature Measurements" by Millar, Uyehara, and Myers and "Compression and End-Gas Temperatures from Iodine Absorption Spectra" by Chen, Uyehara, Myers, and Beck were presented at SAE National Fuels and Lubricants Meeting, Chicago, Nov. 6, 1953. They are available in full in multilithographed form from SAE Special Publications Department. Price each: 35¢ to members, 60¢ to nonmembers).

New Members Qualified

These applicants qualified for admission to the Society between March 10, 1954 and April 10, 1954. Grades of membership are: (M) Member (A) Associate; (J) Junior.

Alberta Group

Lionel MacKenzie Gillies (A), Nyall Gibson Tweedle (M).

Atlanta Group

Holton Robert Parris (A).

Baltimore Section

Edward William Boyce (J), Glenn A. Evans (M), Harry P. Kupiec (M), Edwin T. Plant (A).

British Columbia Section

George Frederick Fuller (A), Frank P. Moran (J).

Buffalo Section

Fred F. Allen (A), Harold E. Wells (M).

Canadian Section

George D. Atkinson (A), Elbert L. Buell (M), John M. Burch (A), R. H. Dexter (A), Howard A. Freestone (M), Roderick D. Macdonald (M), Cornelius Joseph Meredith (M), Robert Davies Shepherd (J), Isaac A. Usher (M).

Central Illinois Section

Samuel Richard Congram (J), Francis H. Hart (M), W. Neil Hediger (J), LeRoy Lichtenstein (J), Chester L. Reid, Jr. (J).

Chicago Section

M. L. Conrad (M), Bertram E. Corning (A), William C. Klitzke (M), Dwight L. Mink (A), Joseph C. Saporito (A), Edward P. Soder, Jr. (J).

Cleveland Section

Einar A. Borch (A), Eric R. Brater (M), Myron R. Day (J), James R. Fotheringham (J), Albert John Garbin (M), Woodrow W. Heigle (M), Joseph C. Lash (M), Leigh Kent Lydecker, Jr. (J), John G. Russell (M),

New Members Qualified

continued

Norman W. Smith (J), Milton R. Vipond (M), Robert H. Wiedenmann (A).

Dayton Section

John I. Covert (J), James C. Cox (M), Gerald B. Jacoby (J), Carl E. Wilkens (M).

Detroit Section

Jerry J. Ahlman (J), Roy Gilbert Baker (A), Arthur Bartlewski (J), Joseph Boyd (M), Tom Bradley (M), Donald E. Brodeur (J), William Hunter Brown (J), Clinton F. Chase (A), Willis M. Clark, Jr. (J), Robert Anthony Cocozella (J), Edward S. Coe (M), Russell Andrew Crane (A), Frederick A. Creswick (J), Walter T. Czuba (M), Roger L. Daniels (J), David Field (J), William Fournier (M), James C. Gagliardi (J), Donald Arthur Garner (A), John Howard Gebo (M), Boyd E. Horne (M), William E. Kracht (J), Joseph P. Kreitmeyer (M), Frank R. Kuzner (J), Norbert Clarence Leppanen (J), T. Harold Lindholm (M), Charles N. Mann (M), Warren H. McAfee (A), Charles R. Olnhausen (M), Glenn T. Purdy (M), William F. Repovz (J), James H. Rogers (M), John D. Rose, Jr. (M), R. C. Sandburg (M), Ray Kenneth Schieb (M), Donald R. Skidmore (M), Howard M. Skovlund (J), Gordon E. Stauffer (J), Annesley W. Stewart (M), George F. Stirrat (M), Donald E. Stueber (J), David O. Thomas (M), Franklin Otto Thomas (J), Elmer F. Trarbach (A), Frank S. Treco, Jr. (J), Charles Louis Trombley (J), Robert H. Wells (J), George O. Wickenden (A), Dean A. Willoughby (J), Carl H. Wolcott (M), William John Zechel (A).

Hawaii Section

Daton Floyd Elzey (A), Fred Y. Fujimoto (A), Edward Y. F. Liu (A), Albert B. Wells (A).

Indiana Section

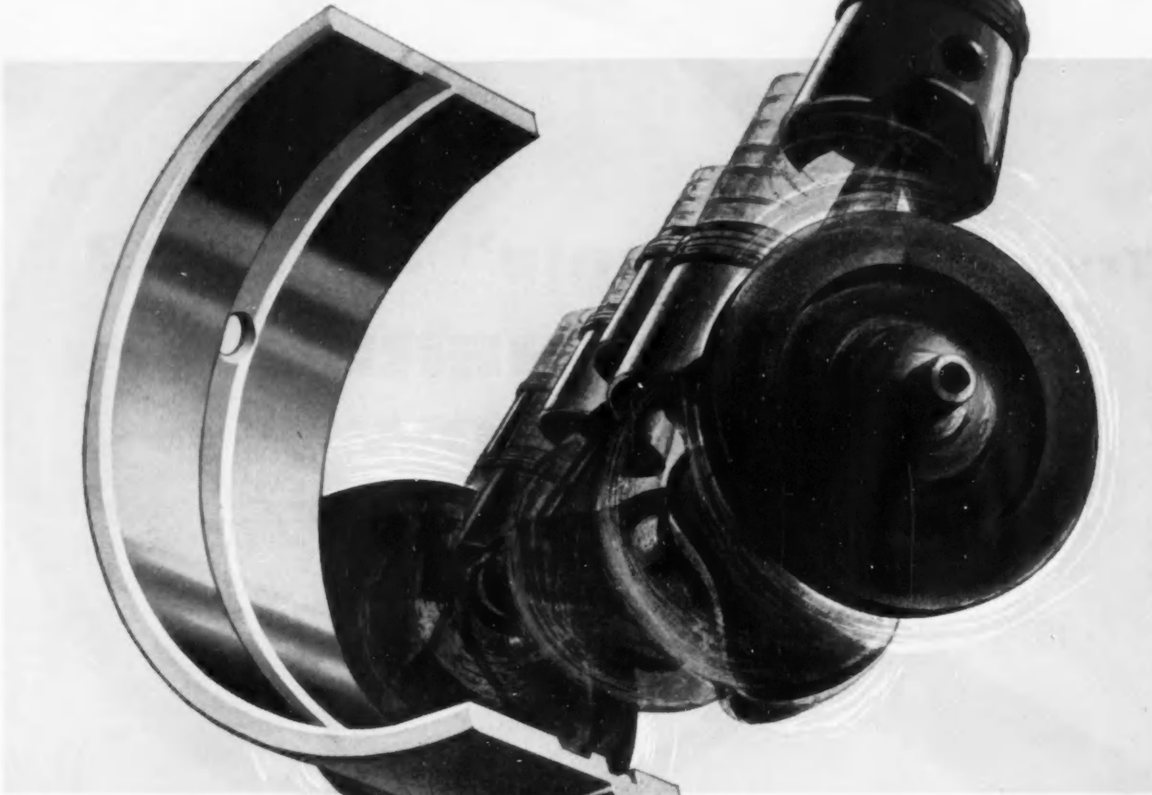
Salvatore J. DiMilla (J), Francis W. Manifold (M), H. H. Puff (M), R. T. Rudolphson (M), Harold B. Tappen (M).

Kansas City Section

Charles R. Campbell (A), S. K. Cannon (M), Darrell D. Don Carlos (M).

Metropolitan Section

A. J. Bette (A), Michael Bialkowski (J), A. H. Boultbee (M), Lt. William



New Members Qualified

continued

Arthur Dailey (J), William H. Dietz (M), Bernard G. Drummond (M), Thomas T. Harrow, Jr. (A), Daniel L. Hertz (A), Norman W. Hibbard (A), Thomas W. Lippert (M), Leonard E. Moody (M), Byron Nierenberg (M), Stanley Osladil (J), Alan Abraham Rawlings (M), Martin L. Razus (A), Norman S. Rice (M), David Wolkov (M).

Mid-Continent Section

Martin J. L. Dobson (M).

Mid-Michigan Section

Dwight H. Buell (A), Sinclair L. Edwards (J), David F. Page (J).

Milwaukee Section

William J. Dooley (M), Douglas Gordon (J), Robert Leonard Lawler (J), Sheldon D. Pollow (M), Benton L. Weichers (A), John Eugene Wieschei (M).

Montreal Section

George N. Armstrong (M), Dave Campbell (M), Frederick Stephen Goodchild (M), Charles Henry Grace (J).

New England Section

Joseph S. Pelles, Jr. (A).

Northern California Section

John A. Copitzky (M), Robert H. Duensing, Sr. (A), Marshall K. Gebert (M), James M. Hait (M), James M. Ray (A).

Northwest Section

Elmore S. Buringrud (M), James A. Crozier (A), Robert M. May (J), Robert Fulton Small (J).

Philadelphia Section

Robert L. Flory (M), Jerry L. Richlak (A), Robert C. Taylor (M), Olin Peter Ten Eyck (J).

Pittsburgh Section

Robert A. Petersen (J).

St. Louis Section

Ben H. Cook (J), Elijah P. Cunningham (M), Eugene R. Livingstone, III (J), Richard C. Wrausmann (M).

CONTINUED ON NEXT PAGE

New Members Qualified

continued

San Diego Section

Edwin Richard Henneberg (J).

Southern California Section

Edward Gerton Boden (J), Frank Wesley Cooper (A), John Dunstan (A), Harry C. Foster (J), Richard M. Frincke (J), Robert Eugene Hutsell (J), Arthur E. Pearson, Jr. (M), Fred Thomas Roberts, Jr. (M), T. M. Sullivan (M), Otis A. Wright (M).

Syracuse Section

Byron C. Motl (A).

Texas Gulf Coast Section

Alexander Cameron English, Jr. (J), Frank C. Love, Jr. (M), Joe Manning (A), Lee E. McDuff (M), Charles F. McGinty (M).

Twin City Section

Ralph C. Brown (M), A. James Samways (M).

Washington Section

Henry Linwood Hutchinson (A), Francis R. Kadie (A), Lt. Comdr. Johan Henri Perie (A).

Western Michigan Section

Gerald W. Brininstool (M).

Wichita Section

C. L. "Chet" Dunbar (A), Harold Emmett Rogers (M).

Outside Section Territory

Leo Joseph Easterbrook, Jr. (M), Porter Landrum (M), Harvey Arthur Larson (J), W. Brooks Linthicum (A), James H. Muncaster (A), Richard Timon Peterson (J), Harold B. Stallings (A), Tom Hyde Thompson (M), O. B. Tuggle (M), R. G. Wendt (M).

Foreign

Robert Edwin Butler (M), Australia; Anthony de Bourbon (J), Brazil; David Lowe Forbes, Jr. (A), India; John Langhard (M), Switzerland; Cedric Philips Lockton (M), England; C. Parthasarathy (J), England; Victor Prati (M), Argentina; Robert H. Whitby (M), England.

Applications Received

The applications for membership received between March 10, 1954 and April 10, 1954 are listed below.

Alberta Group

George Donald Fitzpatrick, Norman George Moreland.

Atlanta Group

Grant F. Jackson.

Baltimore Section

Stephen Palmer Beard.

Buffalo Section

Arthur S. Irwin, Matthew L. Lester, Emmet C. Moynihan, Jr., Gordon E. Peterson, Jerzy Cicero-Pienkowski.

Canadian Section

David C. Barber, Orleand McIntyre, Henry James Mogg, Arthur Raymond Oliver, Ronald Douglas Parkinson, Kenneth S. Stewart.

Central Illinois Section

Frank M. Chiartano, Richard Duane Kieser, Wayne E. Pierson, Robert Eugene Stremmel, Gordon Swardenski.

Chicago Section

Calvin K. Agger, R. L. Branchfield, Leslie A. Dyke, Frederick F. Franklin, John C. Hanna, Clinton R. Hummer, J. C. Laegeler, O. J. Larson, William F. Laser, James A. Maguire, Philip R. Matravers, James A. Neese, Eugene B. Raymond, Bernd Richelmann, Walter Stubbs, James Richard Treder, John Roger Tulach, A. G. Weston, J. V. Woolley, Frank R. Vanderlinden.

Cincinnati Section

Robert F. Klein, James D. Stevenson, David Anthony Trayser.

Cleveland Section

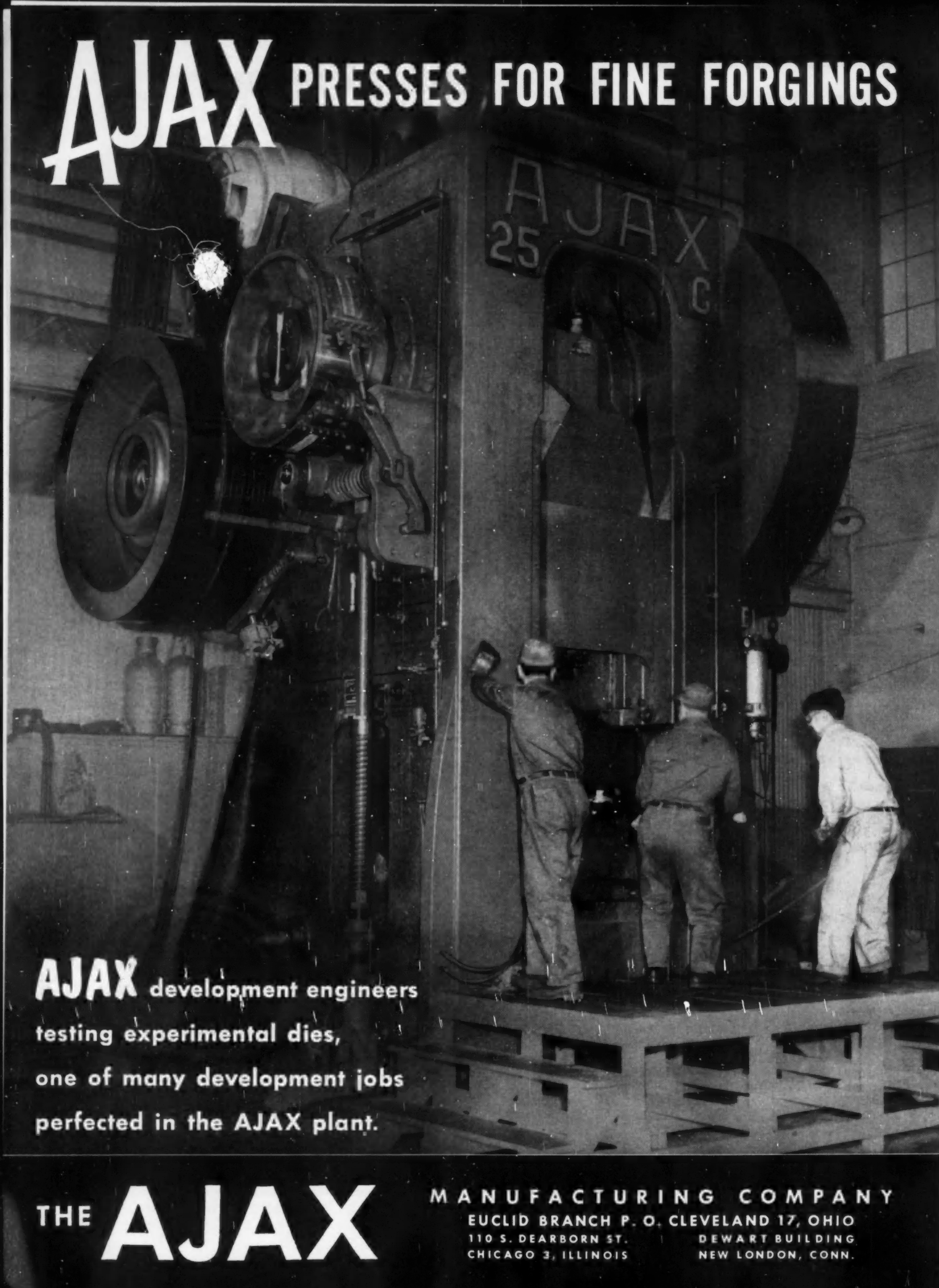
Darold Arthur Augustin, Chester O. Bancroft, John Gerald Greenough, Arthur James Hepler, Melvin P. Hershey, Harold E. Hilty, Charles R. Kilgore, Wayne C. Kunde, John C. Lewis, John R. O'Donnell.

Dayton Section

Howard J. Baier, Lawrence E. Drum, Joseph T. Morris, Kenneth Parker, George A. Vogel.

Detroit Section

George C. Aitken, Harry W. Bielicki, Stanley Bobola, Benjamin Franklin Boehm, Alfred Botti, George James Castle, Bertil Bernard Cederleaf, James D. Brabant, Vincent P. Burns, Bert Walter Cartwright, Robert A. Daniels, Robert E. Day, William A. Delger, Calvin G. Estes, Robert Orrin Field, Emil Norman Gillig, Richard M. Greff, Cecil James Henry Hail, George K. Hammond, Richard Edward Henrich, Peter C. Horner, Bernard C.


AJAX PRESSES FOR FINE FORGINGS
AJAX
25
C
AJAX development engineers testing experimental dies, one of many development jobs perfected in the AJAX plant.
THE AJAX
MANUFACTURING COMPANY
EUCLID BRANCH P. O. CLEVELAND 17, OHIO
110 S. DEARBORN ST.
CHICAGO 3, ILLINOIS
DEWART BUILDING
NEW LONDON, CONN.

Applications Received

continued

Hudgens, Robert D. Jeska, Louis Frank Karayanes, Sr., Stanley A. Kaye, Clarence E. Killebrew, Gerald Klaasen, Jerome Liebow, Robert Kurtz Louden, William V. Luneberg, Harold Hammond Macklin, Jr., Richard Joseph Mandle, Rene C. McPherson, Lawrence E. Miazga, G. E. Muma, Joseph M. Muzzi, David I. Nyquist, J. H. Palmer, Donald J. Peeps, John S. Perrin, Jr., Joseph Pickles, David Potter, Harry L. Redding, Manny Robert Richards, Julius A. Riedl, Albert O. Rominsky, Ormund I. Rugg, Rollin M. Russell, George Stasie, Irvin Stewart, George B. Stingfellow, Alfred E. Taylor, Robert George Tessmer, George Thomas Timoff, Lewis E. Tolan, Woodrow A. Walker, William Dana Wells, Jack Kester Willis.

Indiana Section

George W. Feil, O. F. Gamillscheg, Frederick E. Jones, C. J. Loveless, James A. Nelson, Otakar P. Prachar, Arthur O. Wozencroft.

Kansas City Section

James D. Roden.

Metropolitan Section

Robert Wallace Blake, Charles B. Bleasby, Jr., Lloyd J. Britton, Anthony John Carrano, Allan Chilton, Thomas C. Coyne, Charles B. Goldman, Albert L. Hanson, Ernest A. Linke, William Kennett McKittrick, Isam S. Nimr, Edward M. Powers, Thomas E. Richard.

Mid-Continent Section

Charles Thomas Culbertson, B. M. Salyer, Jr.

Mid-Michigan Section

Bryce L. Stevens, S. Vernon Stoker.

Milwaukee Section

W. W. Bigelow, E. Jack Borisch, Oscar Bromberg, Edward J. Gaffney, William L. Giles, John W. Poulter, Donald Frederick Titus.

Mohawk-Hudson Group

Jack M. Delfs, Charles W. Hurl, John Bob James.

Montreal Section

Armand Grenier, Nicolae Floresco, G. Harrison.

New England Section

Robert W. MacWilliams, John P. Turner, Jr., Harold E. Wright.

Northwest Section

Ellis C. Hendrickson, Harlowe J. Longfelder, Paul L. Wilson, William K. Zeller.

Philadelphia Section

James F. Armstrong, Philip G.

Applications Received

continued

DeHuff, Robert E. Drake, George E. Kerr.

Pittsburgh Section

Charles A. Cashion, Robert E. Corbett, Charles E. Shields.

St. Louis Section

Rudy F. Schneller, Jerome B. Wegmann.

Salt Lake Group

Hugh A. McLean.

San Diego Section

Walter Jordan, H. K. Lyon.

Southern California Section

Clair R. Baker, John Frank Bartholomew, Robert Royer Bloom, Jack W. Galvin, Herbert E. Musgrove, Jr., Harry Allen Pelton, Richard D. Peterson, Melvin Curtis Sanders.

Southern New England Section

Paul Eugene Brouthers, Warren L. Ellis, William Douglas Viets.

Texas Section

Richard M. Hecht.

Texas Gulf Coast Section

Henry Leroy Overstreet, Jr.

Twin City Section

Everett A. Hansen.

Virginia Section

Earl A. Green, Carmine Lattanze, Thomas L. Sharp.

Washington Section

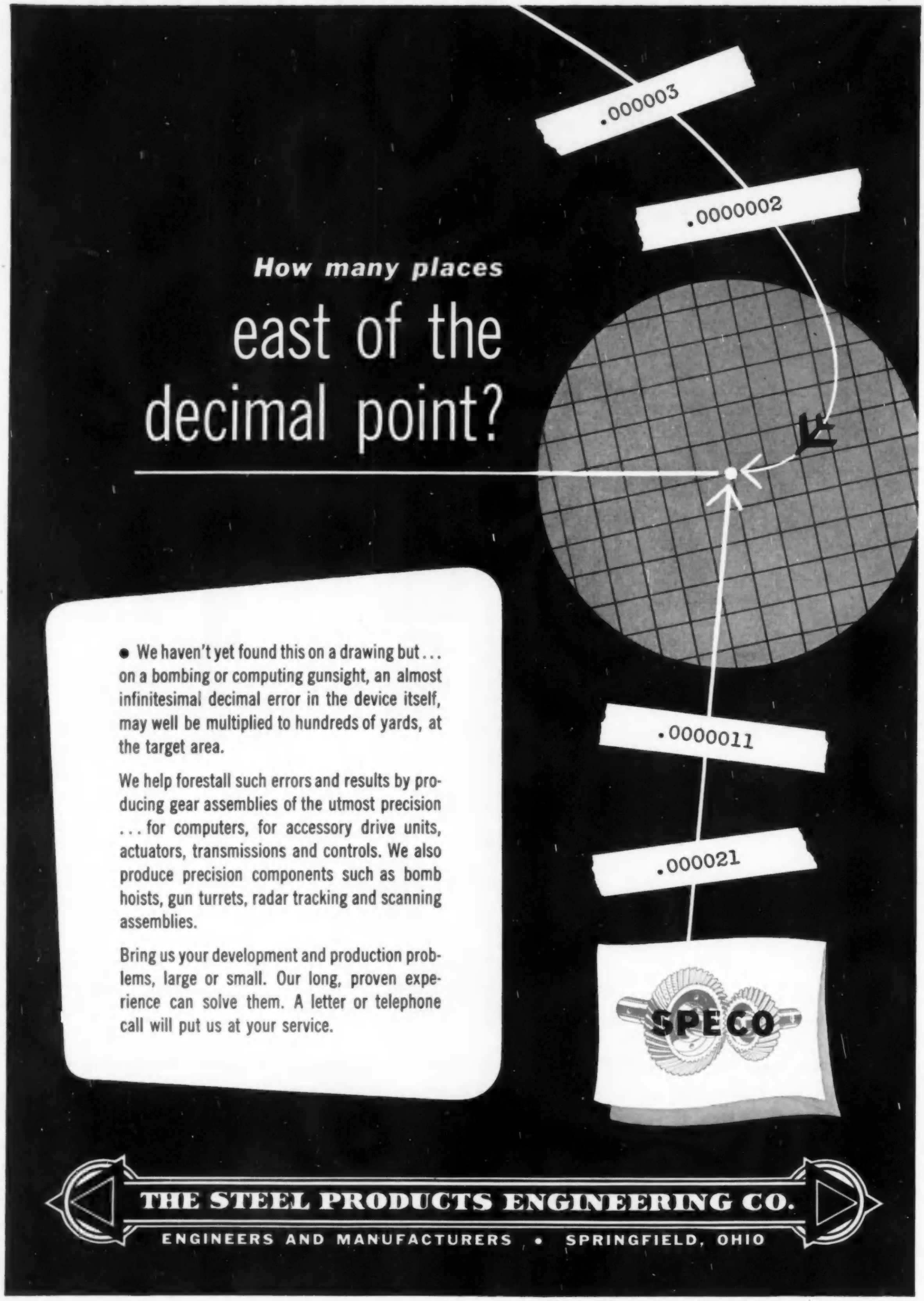
Fanning Miles Baumgardner, Frederick G. R. Cook, Morris B. Flint, John A. Kiefner, Stewart Scott-Hall, Theodore F. Trimble.

Outside of Section Territory

Russell Bell Smith, John D. Blood, Ben Burkart, Cpl. Charles W. Ferguson, Charles F. Froebel, Elliott A. Johnson, G. Lawton Johnson, James R. Johnson, Guy R. Joy, Alphonse Clement LaRiviere, Harold P. Marshall, Charles S. Morrison, William P. Withers.

Foreign

Max John Burkhard, Ceylon; Dr. Alfieri Giulio, Italy; Pierre L. Gousseland, France; Yusuf Fikret Gurturk, Turkey; Russell Ormond Parfrey, W. Africa; P. H. Ramaswamy, India; Sunil Chandra Sen, India.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How many places
east of the
decimal point?
● We haven't yet found this on a drawing but . . . on a bombing or computing gunsight, an almost infinitesimal decimal error in the device itself, may well be multiplied to hundreds of yards, at the target area.
We help forestall such errors and results by producing gear assemblies of the utmost precision . . . for computers, for accessory drive units, actuators, transmissions and controls. We also produce precision components such as bomb hoists, gun turrets, radar tracking and scanning assemblies.
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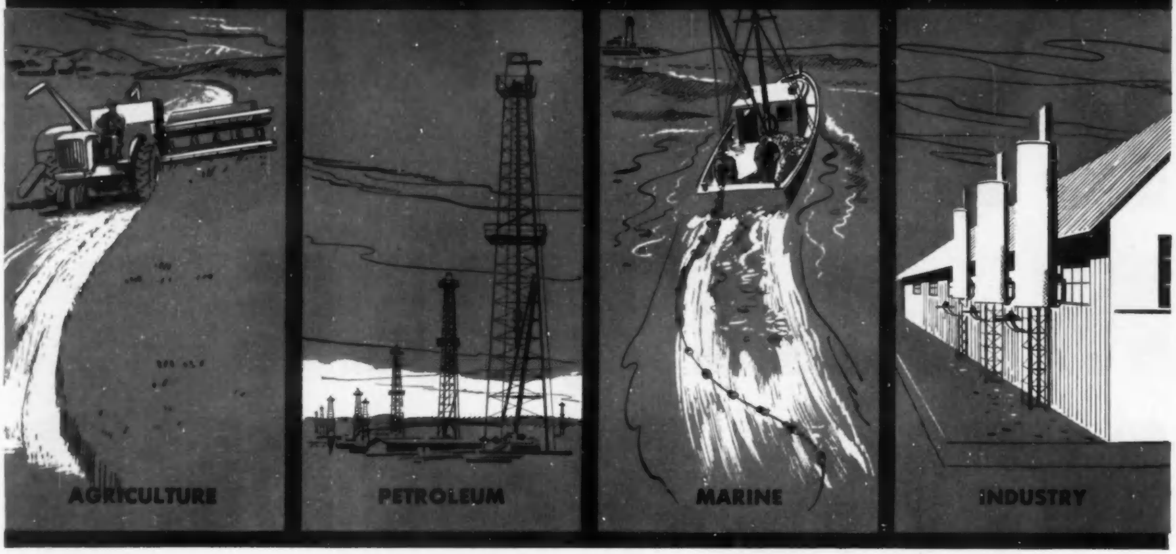

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Bendix
AVIATION CORPORATION

SIDNEY, NEW YORK

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Ring out the old...
ring in the new
"UNITIZED"
chrome plated oil rings
Handles like a one piece ring
Test these unbreakable, all steel CSR-200 rings on your assembly line. See for yourself the extra efficiency, extra economy they provide.
Patent No. 2,140,710
SAVE TIME! . . . Multiple pieces handle like a single unit. Rails and spacer are pre-assembled and "Unitized" for fast, easy installation.
SAVE MONEY! . . . With the new CSR-200, you cut the cost of chrome plated oil rings in half! Fewer engine rejects, increased ring life!
ERROR-PROOF! . . . No fuss, no fumbling . . . it's always correctly assembled. Consists of spacer, two chrome plated rails and expander.
Take a good look at this ring. It's completely new . . . so new, in fact, that it obsoletes all other chrome-plated oil rings! And it's a patented Muskegon development! See how this multiple-piece ring handles like a one-piece ring . . . "Unitizing" makes it possible! A special adhesive holds the pieces tightly together, in the right order, during installation. The adhesive dissolves completely during the first engine run! Look at the tough, gleaming chrome-plated rails—virtually eliminates scuffing, reduces engine rejects, increases oil economy. And what's more, it's available at a remarkable price—half the cost of chrome-plated cast iron oil rings! Test Muskegon's CSR-200 rings in your own engines, in your own laboratory. See for yourself and you'll agree—nothing can equal it! Write us, today!
MUSKEGON Piston Rings
MUSKEGON PISTON RING CO.
MUSKEGON, MICHIGAN
PLANTS AT MUSKEGON AND SPARTA
DETROIT OFFICE:
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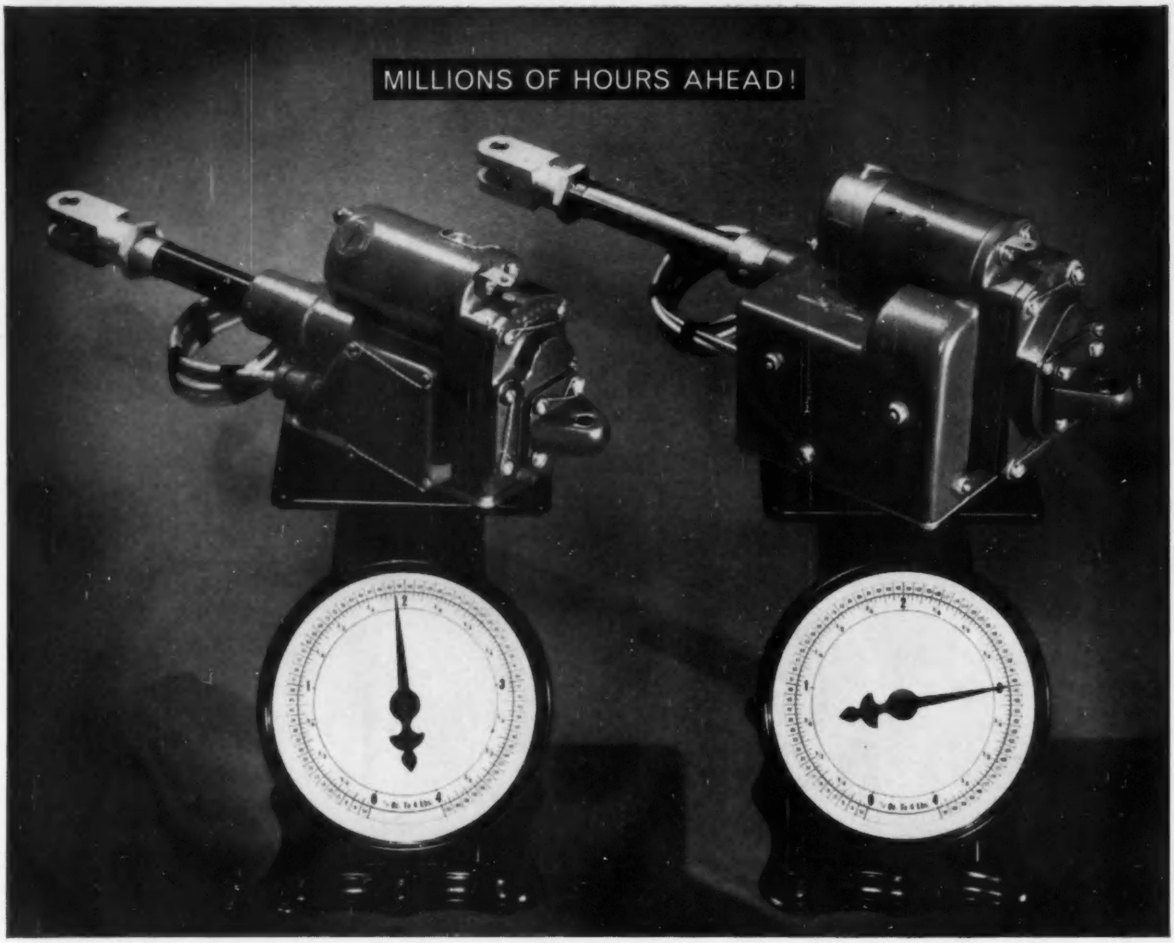
Telephone Trinity 2-2113
Since 1921 "The Engine Builders' Source"



ANOTHER SIGNIFICANT ADVANCE IN

the battle against weight and space!

New, small AiResearch actuator weighs 35% less than old style . . . retains its *high efficiency!* When it comes to equipping a modern jet fighter plane, the saving of an inch of space, or even 17 ounces is *news!*

That's why AiResearch engineers are proud of this new component: a slim, compact linear actuator suitable for thin wing fighter installation. It

New actuator — lighter, smaller:

	New Model	Old Model
Length	11.78 in.	11.78 in.
Width (max.)	1.80 in.	3.10 in.
Height (max.)	3.73 in.	4.49 in.
Weight	31 oz.	48 oz.
Operating load (normal)	500 lbs.	500 lbs.

weighs 35% less than former actuators, with no sacrifice in performance.

During more than a decade of leadership AiResearch has compiled over 700,000 research and development hours in this field alone and produced 419,773 actuating units.

These new actuators are another example of how AiResearch achieves ever greater performance from smaller size and weight at lower cost. If you have a problem in any of the fields listed below, consult our engineering-manufacturing team.

AiResearch Manufacturing Company

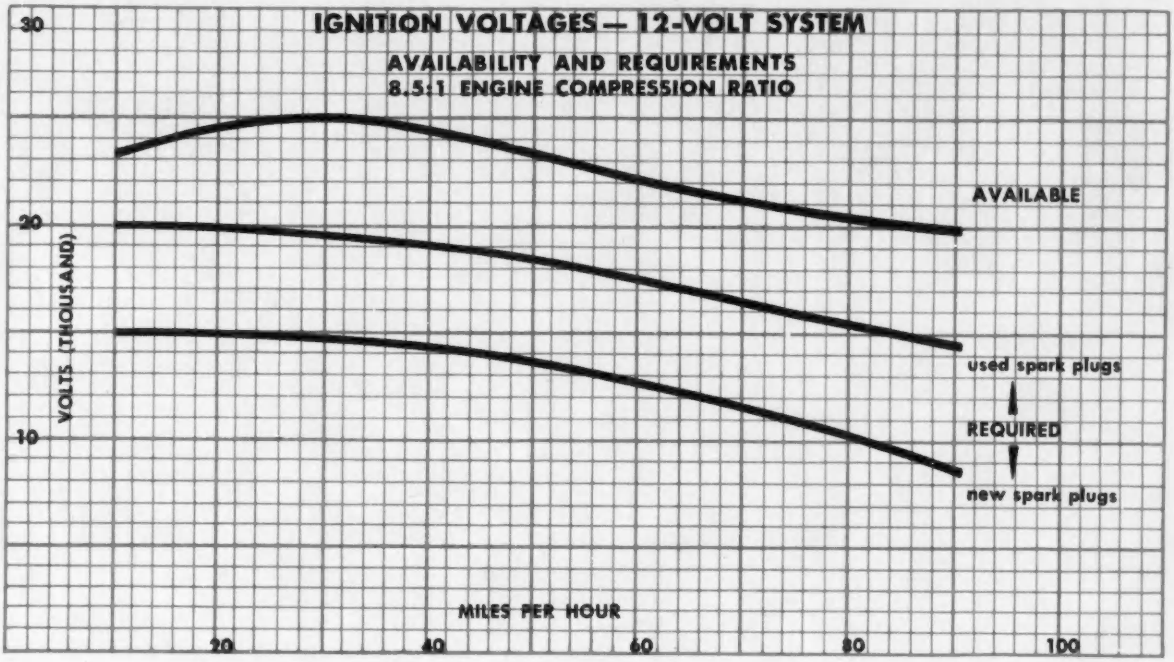
A DIVISION OF THE GARRETT CORPORATION

LOS ANGELES 45, CALIFORNIA • PHOENIX, ARIZONA

Designer and manufacturer of aircraft equipment in these major categories

Makes the Difference

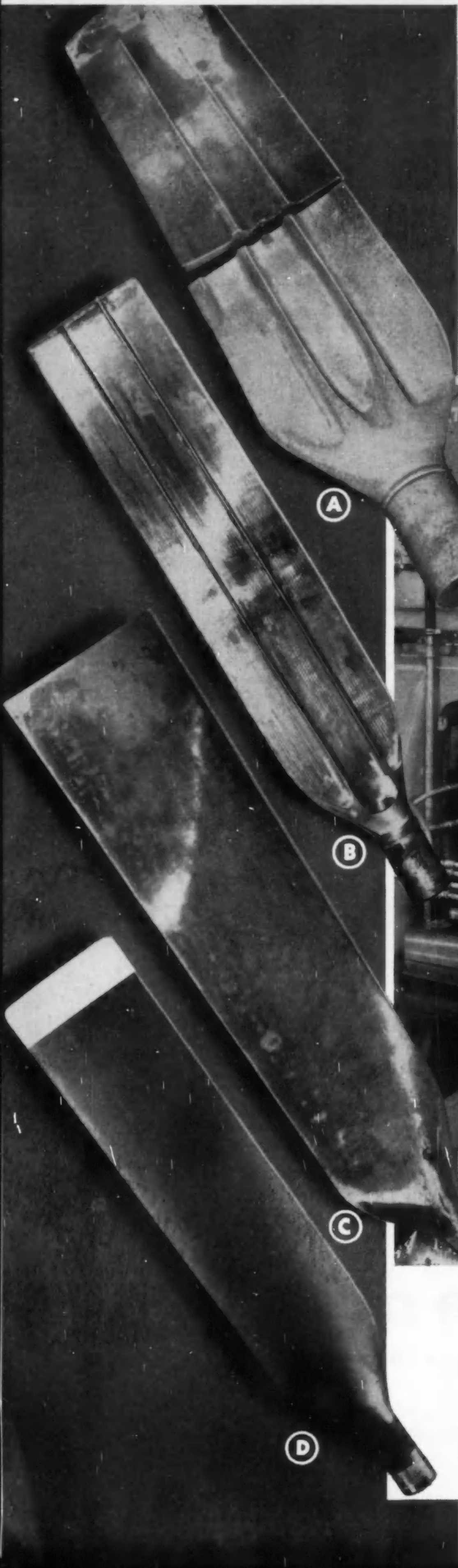
ASSURES HIGHER VOLTAGE AT ALL ENGINE SPEEDS WITH DELCO-REMY 12-VOLT SYSTEM

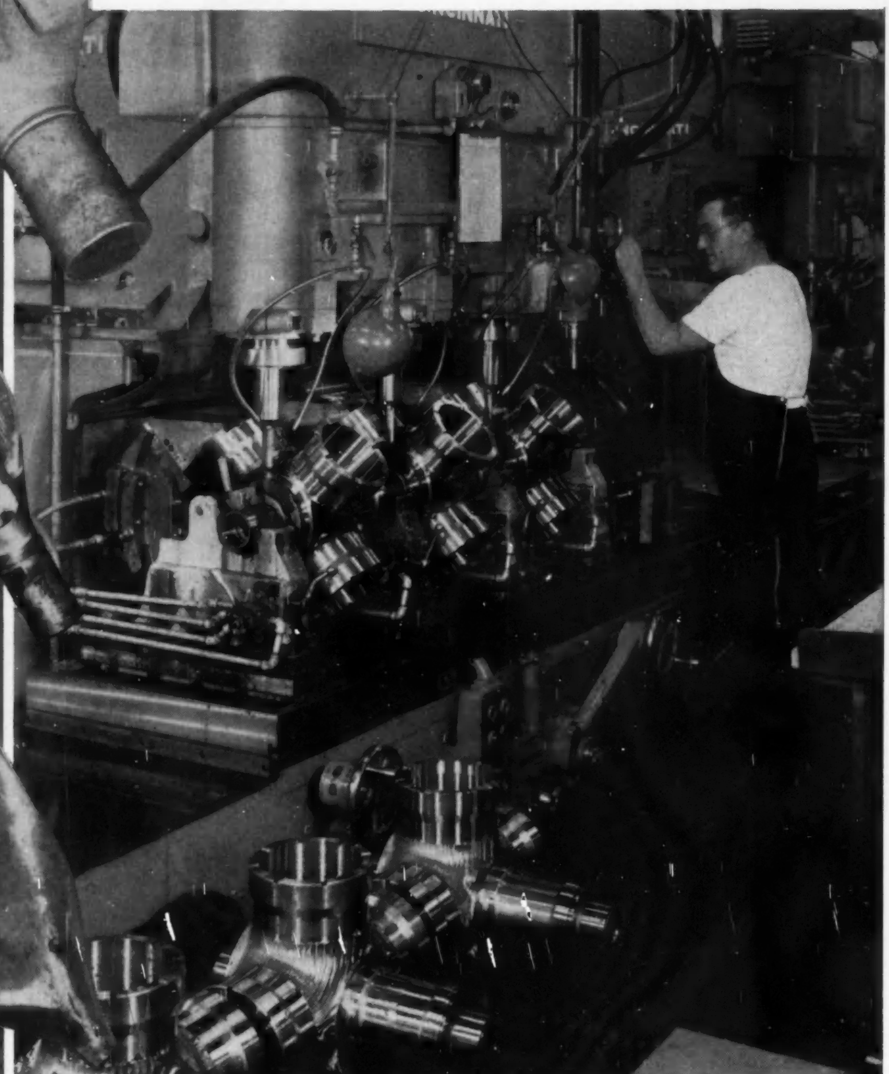


size. During cranking, the resistor is automatically by-passed, and the coil is connected directly to the battery. This makes full voltage available for ignition and thus helps to assure quicker, easier starts. As soon as cranking ends, the resistor circuit is restored for normal operation. Because of its constant-resistance characteristic, this resistor protects the distributor contact points from excessive current at low temperatures.

It is through such Progressive Engineering that Delco-Remy succeeds in being always abreast—usually ahead—of developments in the automotive industry. Whenever the need arises for further advances in electrical equipment, count on Delco-Remy to be ready.

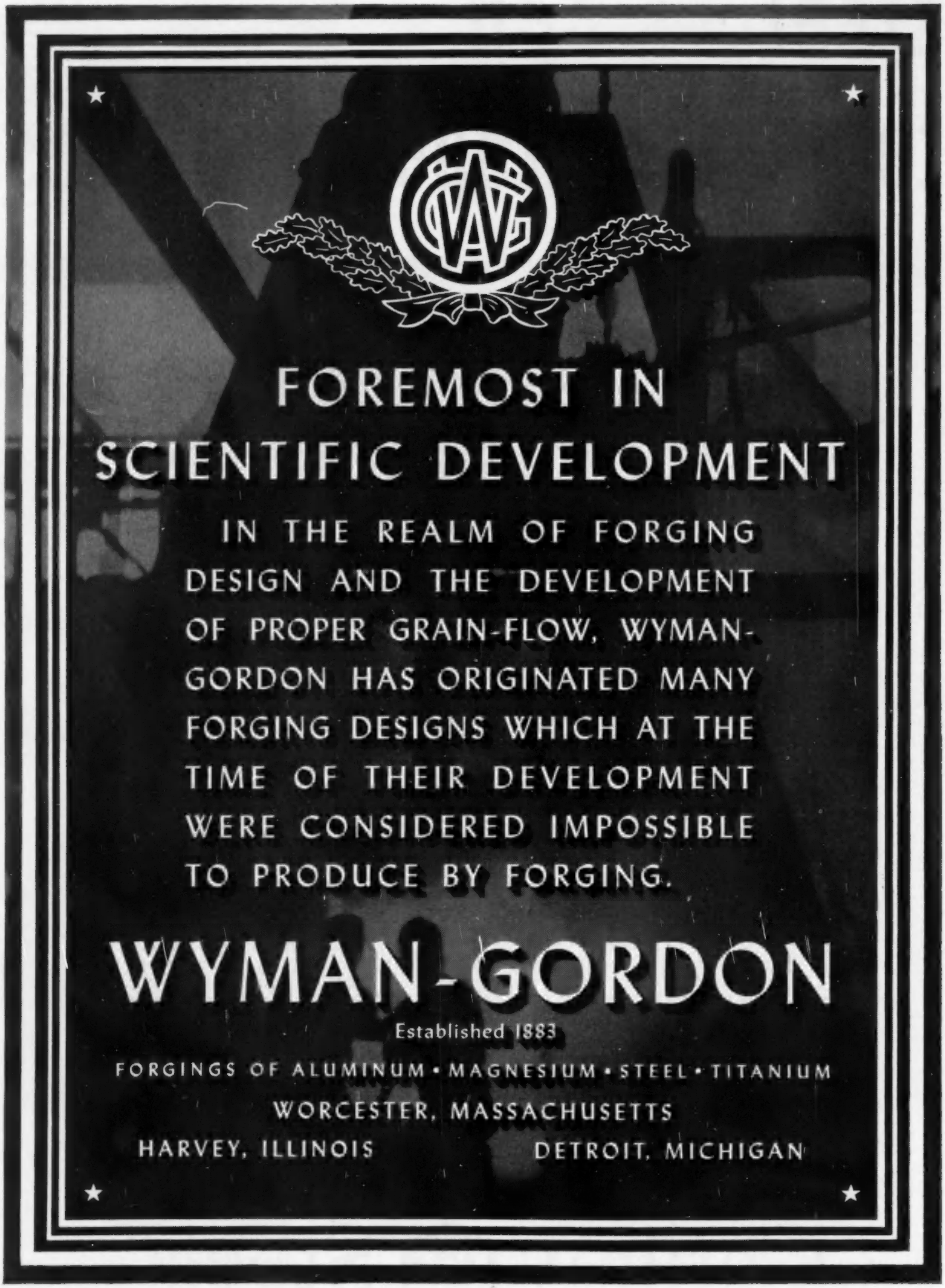
USS Carilloy passes rigid





THESE HIGH QUALITY aircraft propeller hubs are forged and machined from semi-finished Carilloy 4340. They meet extremely tough magnaflux requirements.

FOR BIG PROPELLERS, 2 forged sections **(a)** are welded together to form one blade thrust member. Pieces are then ground and magnafluxed, Kellered, ground, and magnafluxed again **(b)**. Mill camber sheets **(c)** then are copper brazed to the thrust members. Entire unit is heat treated and polished before final magnaflux test and cadmium plating. Rigorous magnaflux testing assures that every finished blade **(d)** can withstand the tremendous stresses encountered on the latest high-speed planes.

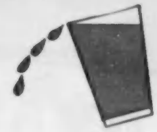

FOREMOST IN
SCIENTIFIC DEVELOPMENT
IN THE REALM OF FORGING DESIGN AND THE DEVELOPMENT OF PROPER GRAIN-FLOW, WYMAN-GORDON HAS ORIGINATED MANY FORGING DESIGNS WHICH AT THE TIME OF THEIR DEVELOPMENT WERE CONSIDERED IMPOSSIBLE TO PRODUCE BY FORGING.
WYMAN-GORDON
Established 1883
FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM
WORCESTER, MASSACHUSETTS
HARVEY, ILLINOIS
DETROIT, MICHIGAN

A Glass of Water Explains How Holley Engineers Took the Stalling Out of Sudden Stops

The simple thing you've seen a hundred times—a full glass of water spilling over the sides when carried—explains the reason for a common driving annoyance. Abrupt stops and fast starts frequently cause engines to miss or stall. The reason: the same spilling action in a glass of water occurs in ordinary carburetors with off-set fuel bowls. Abrupt stops and starts pull gasoline away from fuel intakes, starving the engine, or spill quantities of gas into the manifold, flooding the engine.

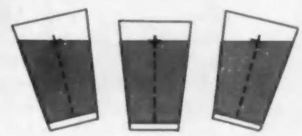
Holley, working closely with automotive engineers, designed the first concentric type carburetor. Again, the basic theory comes from a glass of water. The depth of the water over the center of the bottom of the glass will remain the same even when the glass is tilted at extreme angles. Thus, by locating all fuel intakes at the center line of the fuel bowl, the engine is always assured of the proper amount of gasoline during fast stops, fast starts, on sharp turns, or when starting on a steep grade. Similarly, the location of the fuel intakes close to the venturi in the Holley off-set bowl carburetor has reduced this driving annoyance on volume cars.

Holley's proven experience in designing increasingly efficient carburetors to meet the requirements of modern engines has produced a record of "firsts" unmatched in the industry. So—if you're wondering how to do a job of fuel metering better and more efficiently, call Holley's Carburetor Engineers. Let them listen, test, recommend and design.

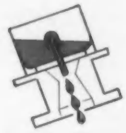


A glass of water explains engine stalling during quick stops and difficult starting when parked on angles. When tipped or carried, water spills over the edge of the glass.

Much the same action takes place in the fuel bowl of a standard carburetor. An abrupt stop or start changes the fuel level forcing gasoline into the manifold, flooding the engine, or—pulls gasoline away from fuel intakes, starving the engine.



The solution to the problem is also graphically explained by the water glass. The depth of the water over the center of the bottom remains the same, no matter which way the glass is tilted.



By locating fuel intakes at the center line of the carburetor fuel bowl, the engine is always assured of the proper amount of gasoline for smooth, efficient performance. This is called true concentric carburetion. Holley Centri•Flo and Centri•Quad carburetors are true concentric design.

HOLLEY Carburetor Co.

VAN DYKE, MICHIGAN

WORKING WITH AUTOMOTIVE ENGINEERS TO INCREASE STANDARDS OF PERFORMANCE AND ECONOMY FOR MORE THAN HALF A CENTURY

RYAN builds ROCKET MOTORS for 3000 mile-per-hour missiles

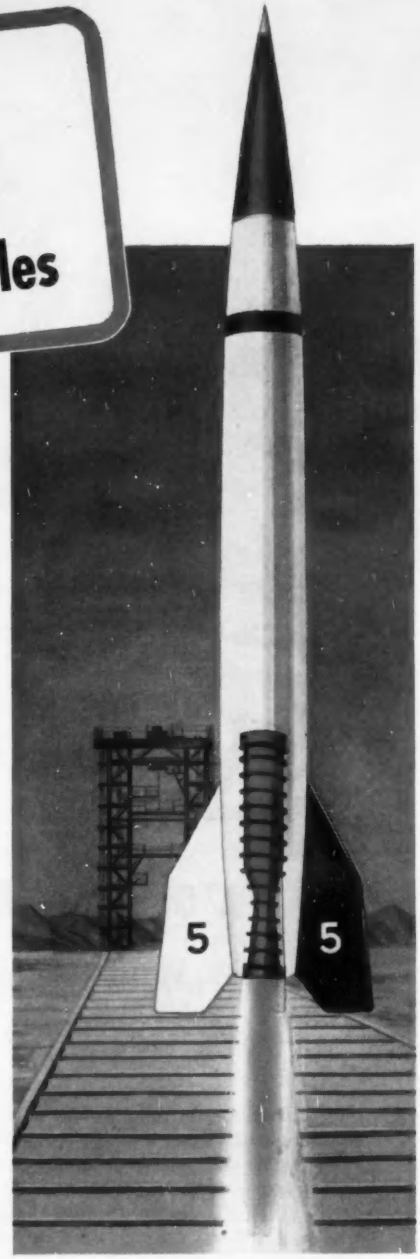
IMAGINE a motor powerful enough to propel a missile at speeds exceeding 3000 mph . . . so powerful that its developed thrust can amount to tens of thousands of pounds. One of Ryan's most challenging current assignments is the complete production of such a motor for an Army Ordnance surface-to-surface missile.

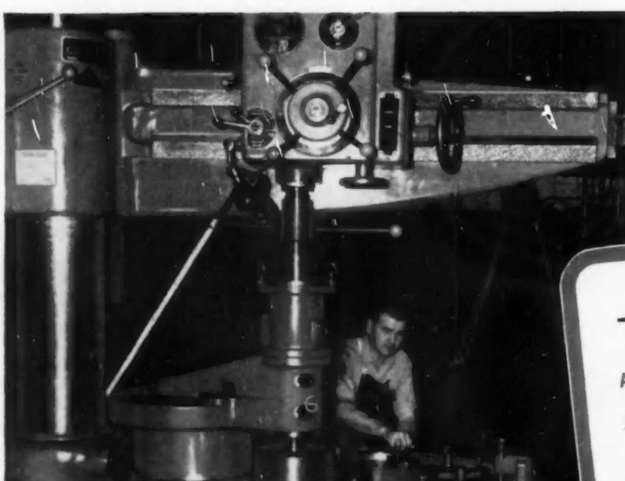
There was a many-sided problem of fabrication, welding and machining that Ryan had to solve in connection with rocket motor manufacture. Because a rocket motor is capable of burning as much as a ton of fuel a minute at temperatures up to 5000 degrees F., terrific internal pressures are created that must be contained in a very compact package of complex construction and exacting dimensions.

The solution was found in perfecting new techniques for forming, welding and machining the special alloy materials. Ryan devised new methods of controlling work to very close tolerances; ingenious electric resistance and arc welding processes and a better furnace brazing system . . . plus intricate machine operations that had to be jewel-like in precision.

Ryan's proved ability in the production of complete rocket motors is due in large measure to its long experience in building the "hot end" of jet and piston engines. Its versatility in many specialized fields is an important advantage in each new assignment, for it enables every division to draw on 31 years of fi t hand experience in the most advanced phases of aviation engineering and production.

Thus, each year more unique technical engineering and production projects are awarded Ryan . . . an integrated company with superior abilities in meeting the challenges of today's high-speed air age.





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INGENIOUS
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Exhaust Systems for Aircraft
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Ceramics for "Hot Parts"

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PIONEERS IN EACH ★ LEADERS IN ALL

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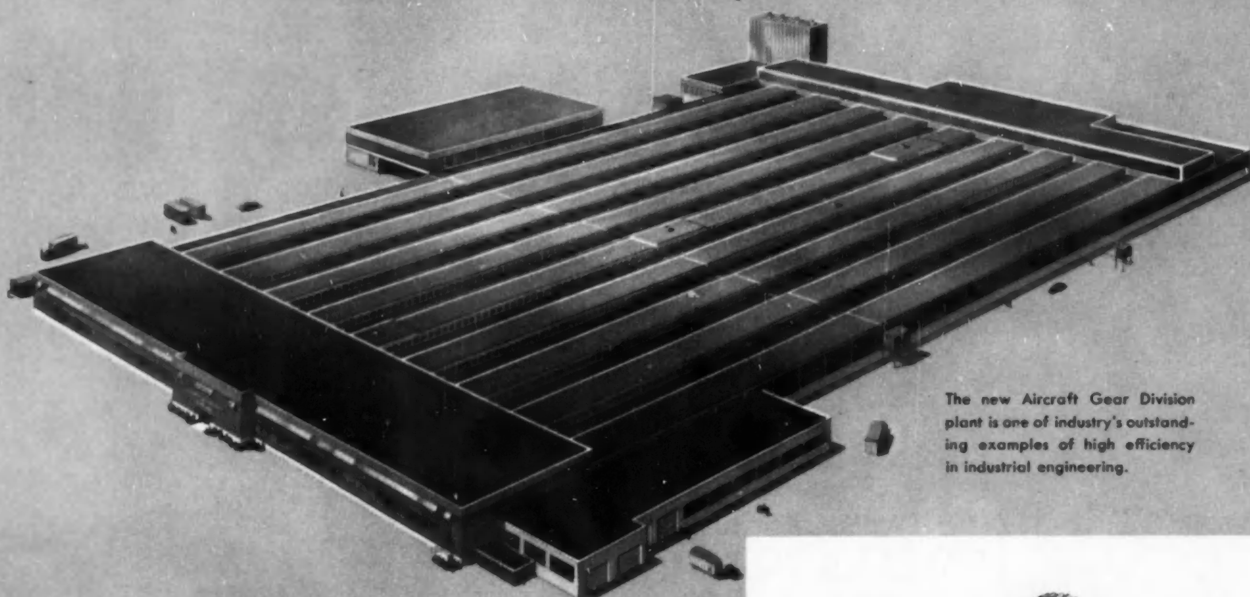
THIS IS THE AIRCRAFT GEAR DIVISION IN FORT WAYNE, INDIANA



The new Aircraft Gear Division plant is one of industry's outstanding examples of high efficiency in industrial engineering.

PRECISION GEAR PRODUCTION

complying with the most rigid military and aircraft engine producers

The Aircraft Gear Division plant was built by the Dana Corporation for the specific purpose of manufacturing gears and similar parts, and complete gearing assemblies, to the finest precision standards.

This ultra-modern plant carries into the aircraft field the Dana-Spicer tradition of ingenuity, quality and service, which has become so firmly established in the automotive industry during the past 50 years.

Look to Dana and Spicer for excellence in engineering . . . careful manufacturing . . . and everyday well-managed administration of service.

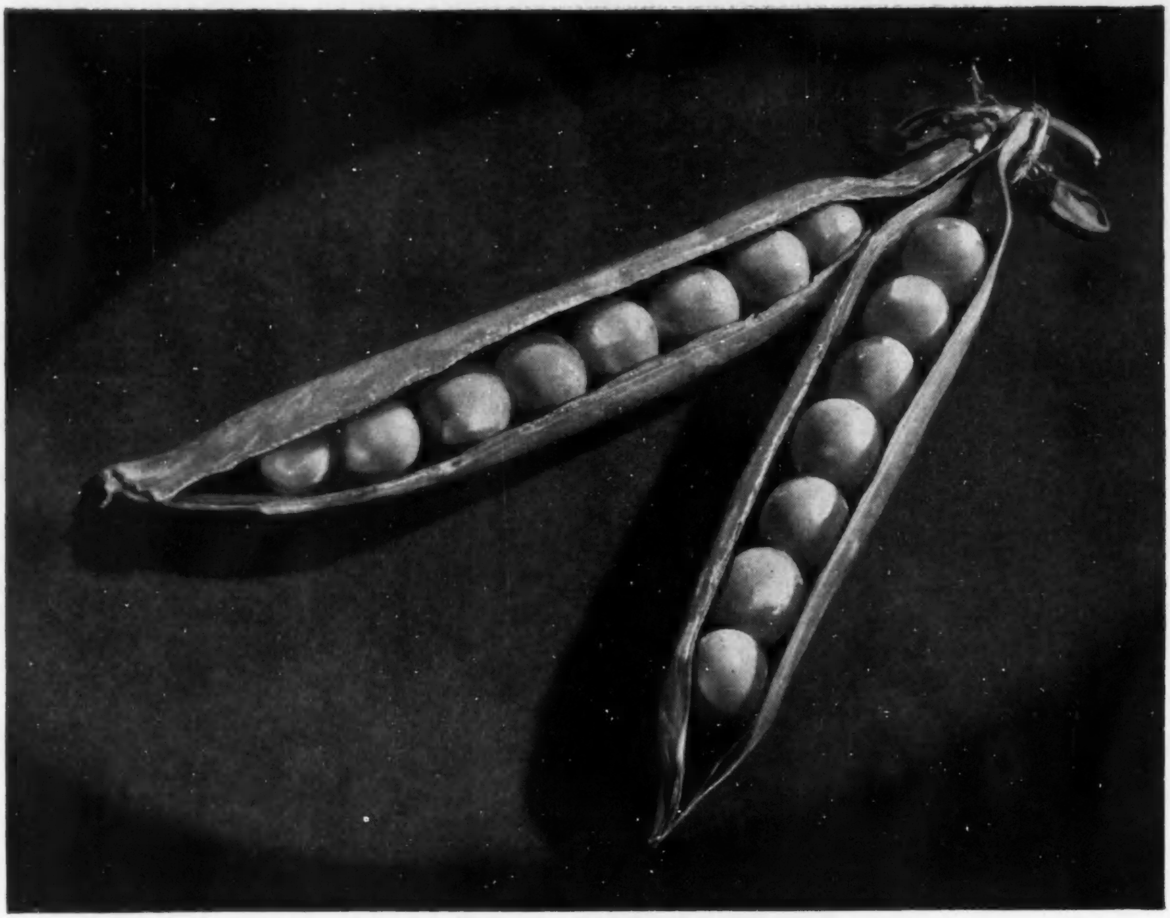
SPICER MANUFACTURING DIVISION
of Dana Corporation • Toledo 1, Ohio

SPICER MANUFACTURING DIVISION 50th ANNIVERSARY 1904-1954 DANA CORPORATION

50 YEARS OF Spicer SERVICE

ENGINEERING DANA MANUFACTURING

TRANSMISSIONS • UNIVERSAL JOINTS • PROPELLER SHAFTS • BROWN-LIPE and AUBURN CLUTCHES • FORGINGS • AXLES • STAMPINGS • SPICER BROWN-LIPE GEAR BOXES • PARISH FRAMES • TORQUE CONVERTERS • POWER TAKE-OFFS • POWER TAKE-OFF JOINTS • RAIL CAR DRIVES • RAILWAY GENERATOR DRIVES • AIRCRAFT GEARS • WELDED TUBING



Alike as two peas in a pod

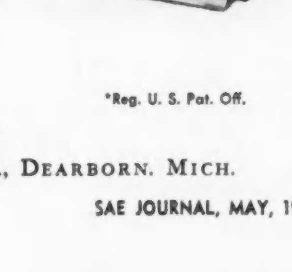
. . . these auto radios as they come off our assembly line

If you have a cost reduction problem . . . here's one way to keep quality up . . . and prices down, specify Bendix* Radio.

Some two million of them have come off what has been called, "one of the world's finest radio production lines." And why not?

Behind it stands more precise electronic experience than any other set you can buy.

Low maintenance cost and trouble-free operation makes dealers and customers happy, too. Made by Bendix . . . the name millions trust.



Bendix Radio

*Reg. U. S. Pat. Off.

DIVISION OF BENDIX AVIATION CORPORATION

BALTIMORE 4, MARYLAND

14940 MICHIGAN AVE., DEARBORN, MICH.

1,000,000th Safety POWER STEERING UNIT built by Saginaw!

You want it for ease— You need it for safety!

The one-millionth Safety Power Steering gear by Saginaw comes off the assembly line—April 9, 1954

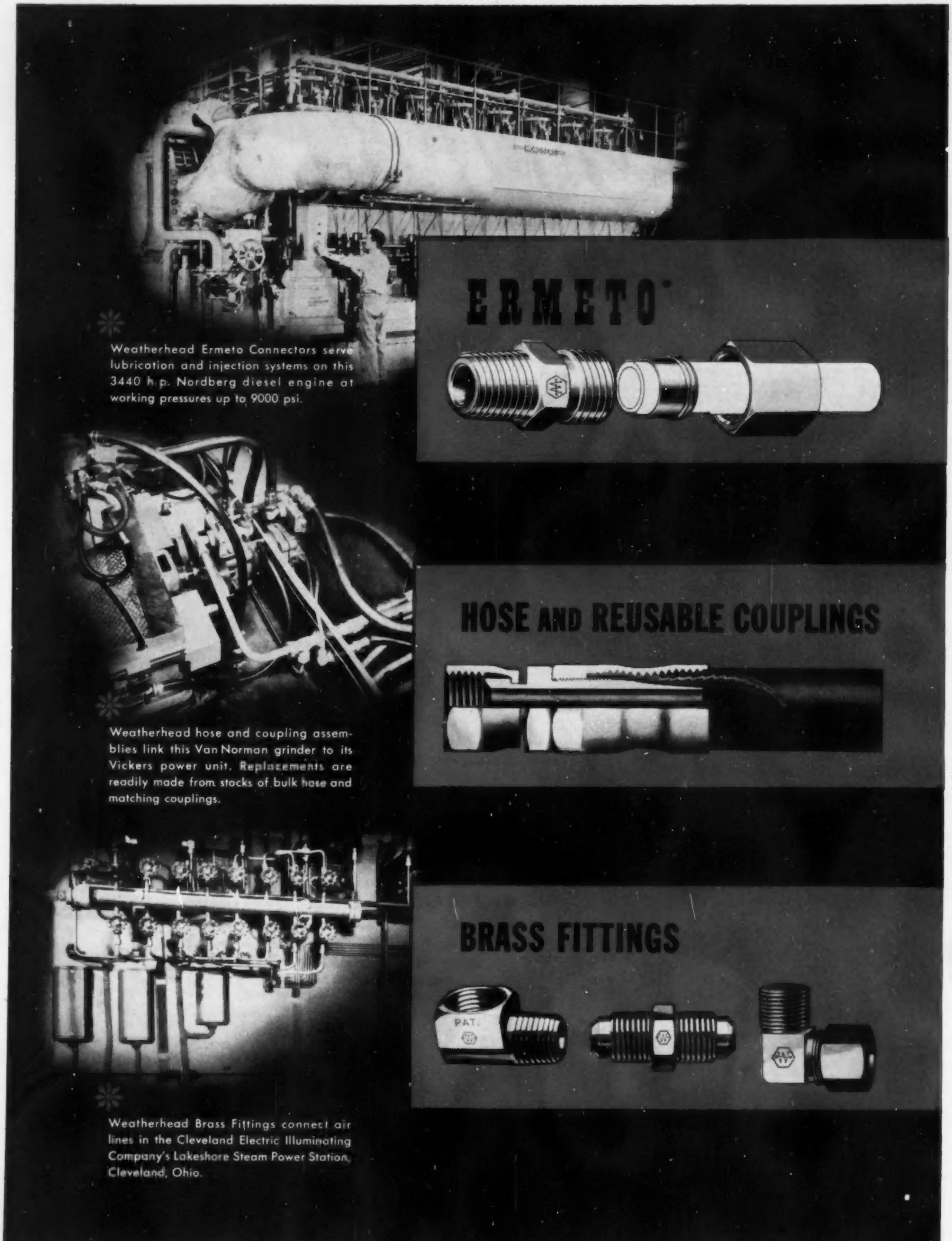
On November 28, 1951, the first Power Steering gear for General Motors passenger cars left our assembly line. We knew it was good—but even we were amazed as production schedules had to be revised up and up and *up again* to keep pace with the ever growing demand.

On April 9, 1954, we produced our *one-millionth* unit. In just a little over 28 months a new era of driving ease and security has been born. A million motorists now turn and park their cars with fingertip ease they never dreamed possible. What's more, they cruise the highways *relaxed* both mentally and physically—secure in the knowledge that *Safety* Power Steering will help keep their cars under control in any emergency—*even a high-speed blowout!*

Today *Safety* Power Steering is standard equipment on every Cadillac and Buick Roadmaster—and available at a *new low price* on all other General Motors cars. Today Saginaw builds more Power Steering gears than all other makers put together—for *never in automotive history has any innovation won such unprecedented public acceptance in so short a span of time!* Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan.

Safety POWER STEERING BY Saginaw

FEATURED BY CADILLAC, BUICK, OLDSMOBILE, PONTIAC, CHEVROLET CARS—GMC TRUCKS


Weatherhead Ermeto Connectors serve lubrication and injection systems on this 3440 h.p. Nordberg diesel engine at working pressures up to 9000 psi.
ERMETO
Weatherhead hose and coupling assemblies link this Van Norman grinder to its Vickers power unit. Replacements are readily made from stocks of bulk hose and matching couplings.
HOSE AND REUSABLE COUPLINGS
Weatherhead Brass Fittings connect air lines in the Cleveland Electric Illuminating Company's Lakeshore Steam Power Station, Cleveland, Ohio.
BRASS FITTINGS
PAT.

IF IT'S PETROLEUM-POWERED
there's a Globe-built battery... right from the start
GLOBE
Because road maintenance crews demand fast, sure starts...
LE ROI uses GLOBE
batteries for these compressors
... it's important news to makers of automotive equipment
How does the fact that Le Roi uses Globe-built batteries apply to you? Simply, the answer is this ...
On the job, the work of anywhere from two to twenty or more men hinges on the compressor. If it starts, they work. If it's balky, they stand around and it begins to cost somebody big money.
One of the ways Le Roi offers prospects and customers more efficiency and lower costs is to take every precaution possible to see that a Le Roi *always* starts. They use Globe batteries — the batteries proved to have extra dependability, the reserve power required to turn over the most stubborn engines in any weather.
So ... if you're not already using Globe batteries, take a hint from men who measure starts in terms of profits. Specify Globe and be sure your equipment is *right from the start!*
LE ROI
GLOBE-UNION INC.
MILWAUKEE 1, WISCONSIN
GLOBE BATTERY PLANTS ARE LOCATED AT:
ATLANTA, GA. • BOSTON, MASS. • CINCINNATI, OHIO • DALLAS, TEXAS • EMPORIA, KANSAS • HASTINGS-ON-HUDSON, N. Y. • HOUSTON, TEXAS • LOS ANGELES, CALIF. • MEMPHIS, TENN. • MILWAUKEE, WIS. • MINERAL RIDGE, OHIO • OREGON CITY, ORE. • PHILADELPHIA, PA. • REIDSVILLE, N. C.

Many a manufacturer has chosen Packard cable and wiring assemblies solely because of Packard's uniform high quality—and has been pleasantly surprised to receive important *extra advantages*. For Packard provides experienced engineering counsel, production capacity sufficient for any need, and assured on-time delivery . . . and often it is intangibles such as these that help keep your production lines going.

Consider Packard as a source

The widespread use of Packard cable and wiring assemblies, by America's foremost automotive, aviation and appliance manufacturers, is your assurance of high quality. And, because Packard is equipped to turn out 7,000,000 feet of finished cable and 800,000 wiring assemblies *daily*, you can depend on unfailing delivery. In addition, Packard's large staff of engineers is ready to serve you at any time. Call on them—preferably while your new product or model is still on the drafting board. Their long experience in designing and fabricating cable and wiring assemblies can well result in important savings to you.

Packard
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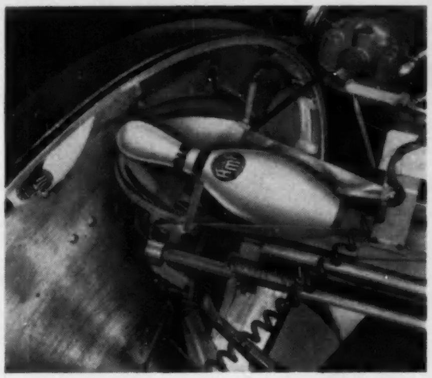
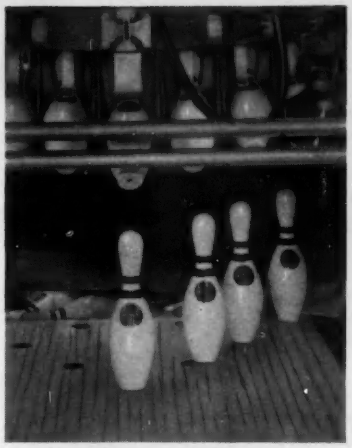
TRADE MARK

Packard Electric Division • General Motors Corporation • Warren, Ohio

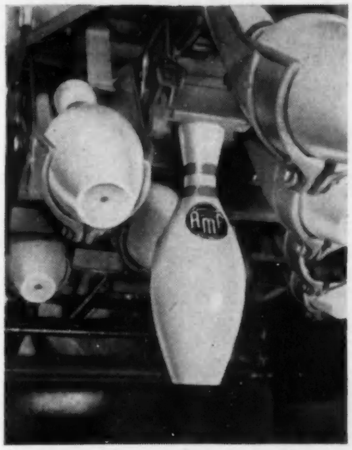
AVIATION, AUTOMOTIVE AND APPLIANCE WIRING



"**Pinwheel**" lifts pins from pit to distributor which delivers them into die cast spotting cups (left). Other Doehler-Jarvis castings are used to guide rods that clamp pins to "pinwheel" and to mount distributor head (above).



Standing pins moved off spot by first ball, must be held above pin deck for return to same position for second ball while deadwood is swept away. How the pinspotter accomplishes this is shown below.



Sponge rubber pad, supported in a Doehler-Jarvis die casting, locates the "off-spot" pin, grasps it, lifts it, and puts it down exactly where it was before, thus conforming with one of the game's most rigid rules.

automate bowling...

It could be prohibitively expensive . . . A production man's nightmare.

But American Machine & Foundry Company found ways to keep costs down. Right at the start they brought Doehler-Jarvis into the picture.

Together, engineers from both companies went over the prototype piece-by-piece, operation-by-operation... looking for the best ways to keep machining and weight down, precision and durability up.

The result of these meetings of minds? Doehler-Jarvis is die-casting 99 parts for the pinspotter. At AMF's plant, a hole may be tapped or a light finish cut made . . . but the bulk of the machining and a good deal of expense is avoided. As one AMF engineer puts it, "anytime you can eliminate machining today, you're certainly saving money."

Cutting costs for customers, big and little, is a Doehler-Jarvis specialty. Some of the best-known makers of automotive, electrical, communication, household, and office equipment count on Doehler-Jarvis to help them take full advantage of the die casting process.

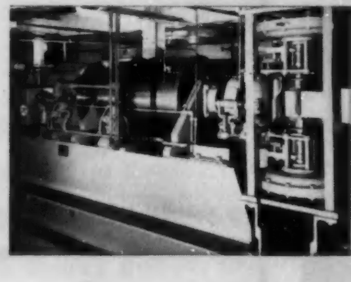
You can count on Doehler-Jarvis, too...to apply to your problem the savvy in die design and parts production developed in our 50 years in this business. Call us in early in the planning stage.

Doehler-Jarvis Division
of
National Lead Company

General Offices: Toledo 1, Ohio

*Reg. U. S. Pat. Off.


Really Rugged
THE CLARK BUS TEAM
ACCURATE
DURABLE
EFFICIENT
ECONOMICAL
This rugged combination — Clark Axles, front and rear, and Clark Transmission — is a practical answer to load carrying capacities and steering requirements, also to the question of power transmission from engine to tires. It's also another clinching argument that it's good business to do business with Clark.
CLARK EQUIPMENT
CLARK EQUIPMENT COMPANY, BUCHANAN,



The INERTIA FLYWHEELS, a useful feature of the Petroleum Laboratory's chassis dynamometer, simulate the "load" on the car or truck being tested. The two large wheels on the right represent 2,000 pounds each, the next one is 1,000 pounds, and a 500-pound wheel is shown on the left. Operated separately or in varying combinations through the transmission, the flywheels can be used to simulate any vehicle weight from 500 to 5,500 pounds in multiples of 500.

DEVELOPING FUELS AND LUBRICANTS FOR TOMORROW'S CARS calls for extensive road testing. To accelerate this work, the Du Pont Petroleum Laboratory has brought the highway indoors with this complete chassis dynamometer setup.

New superhighway *(laboratory style)* for product application research...

The Du Pont Petroleum Laboratory's new chassis dynamometer installation simulates on-the-road driving conditions.

Superhighways of tomorrow will present hundred-mile stretches for steady high-speed car and truck operation. And bigger cities with bigger traffic tangles will increase the wear and tear of stop-and-go driving on cars. Both of these extremes will make heavier demands on fuel and lubricant performance than do present-day driving conditions.

To help refiners and automotive engineers prepare to meet these demands successfully, the Du Pont Petroleum Laboratory is continuing its extensive research program on additives to improve fuel and lubricant performance.

The chassis dynamometer shown on this page plays an important part in this program. Housed in one of the buildings of the Du Pont Petroleum Laboratory at Deepwater, New Jersey, it functions in a way to *bring the highway indoors.*

With it, engineers can simulate most driving conditions . . . from hill climbing to coasting, from open throttle desert racing to threading slowly through traffic on hot city streets.

Along with other accessories, an adjustable air duct produces typical radiator operating conditions at speeds up to 90 mph. And a set of inertia flywheels simulates various car weights under acceleration conditions.

Engineers operate the dynamometer from a control panel where they record data on the performance of the vehicle as affected by fuels and lubricants, as well as other factors. As information is collected and evaluated, it will be made available to the petroleum and automotive industries.

DU PONT
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Just send for Flexlab Catalog No. 187 covering our Flexlab Laboratory Equipment. It contains much valuable information plus an impressive list of Flexlab users . . . You will find yourself in the best of company when you have Standard design and build your next panel installation . . . Consultation without obligation.
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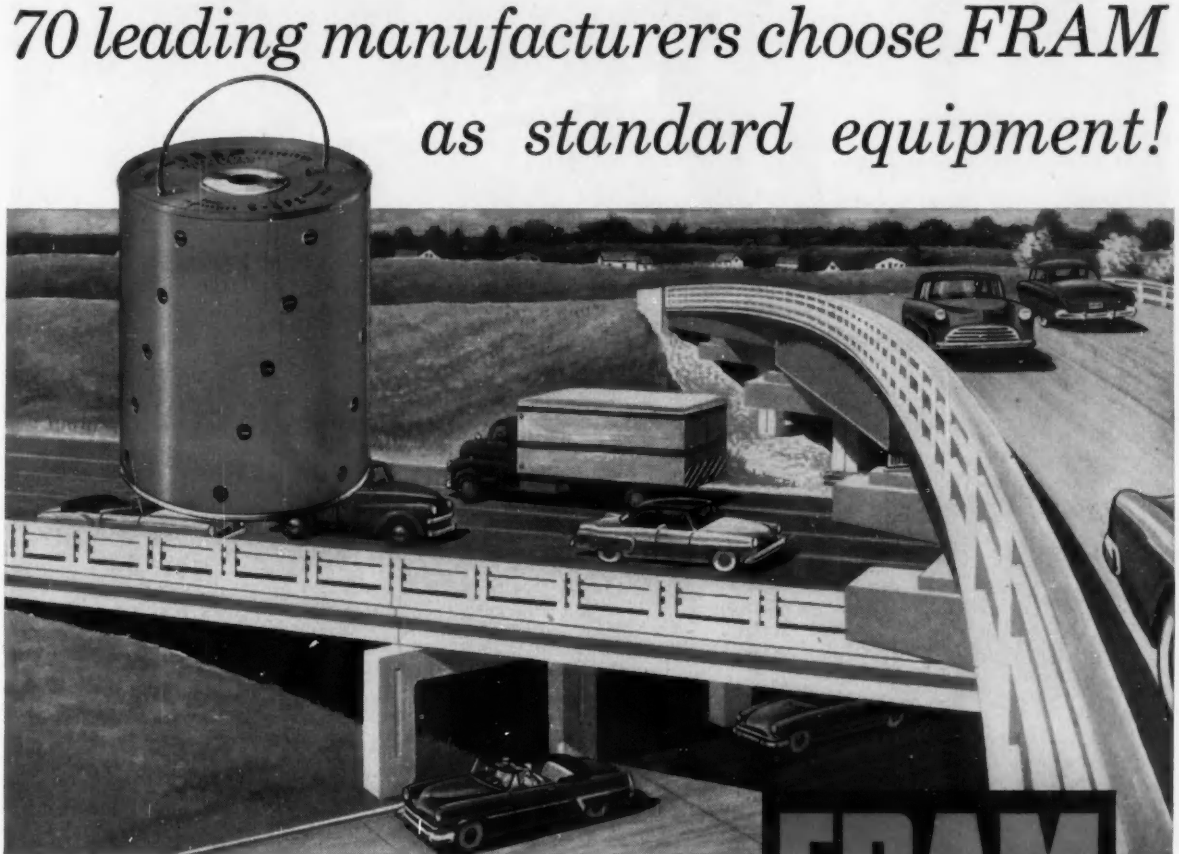
FRAM FIRST
YEAR AFTER YEAR

70 leading manufacturers choose FRAM as standard equipment!



FRAM is standard equipment on more cars, trucks and tractor engines than any other filter in America! Let this record of leadership work for you! Fram engineering and development facilities — including the Fram Dust Tunnel at Dexter, Mich. — are at your disposal. Write FRAM CORPORATION, Providence 16, R. I. Fram Canada Ltd., Stratford, Ont.

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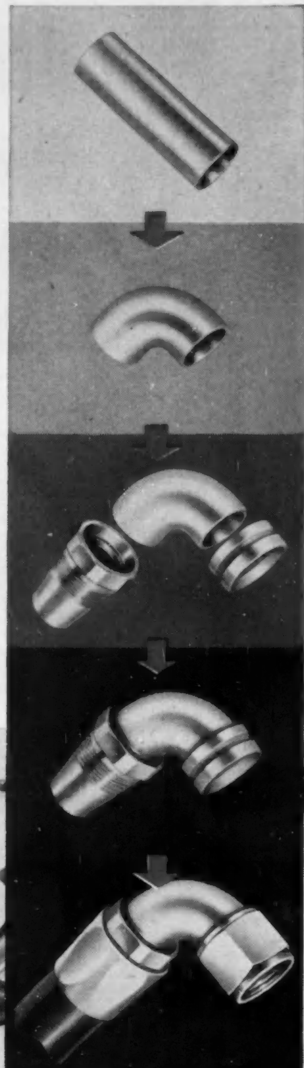
OIL • AIR • FUEL • WATER
FILTERS



What Type Elbows Do You Need Today?

AEROQUIP BRAZED ALUMINUM ELBOW-TYPE HOSE FITTINGS CAN BE MADE TO YOUR SPECIFICATIONS QUICKLY

Specify the elbow that will solve your problem, and Aeroquip will provide the answer, *fast!* With Aeroquip's advanced method of fabricating, thin wall tubing is bent to specification and other components are brazed into an assembly of uniform strength. Features are: extremely tight bend radii, uniform wall thickness, unrestricted flow, and exceptionally light weight. Sizes range from ¼" O.D. to 3" O.D.

Thousands of Aeroquip brazed aluminum elbow fittings are in use on aircraft and engines with 100% user satisfaction. These assemblies are matched with Aeroquip hose for guaranteed performance. Call on us for a quick solution to your plumbing problems.

Aeroquip

REG TRADE MARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

AERO-COUPLING CORPORATION, BURBANK, CALIFORNIA

(A Subsidiary of Aeroquip Corporation)

Manufacturers of Aeroquip Flexible Hose Lines with detachable, reusable Fittings; Self-Sealing Couplings; Brazed Aluminum Elbows

LOCAL REPRESENTATIVES IN PRINCIPAL CITIES IN U.S.A. AND ABROAD • AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

WAUKESHA

THE PAYLOAD POWER PLANT-

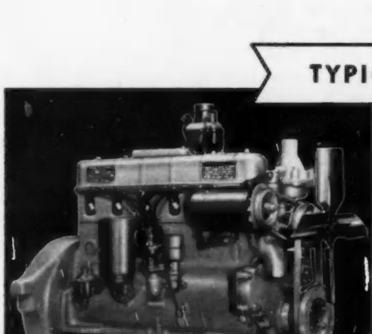
over the road *off the highway*

FAST · SMOOTH · POWERFUL

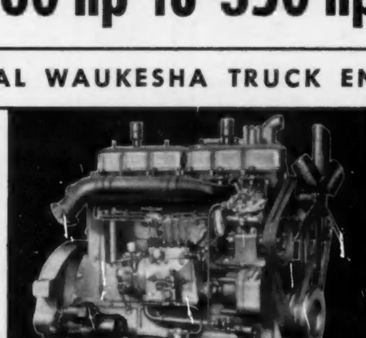
NORMAL AND TURBOCHARGED DIESELS, GASOLINE OR LPG . . .
STANDARD OR COUNTERBALANCED CRANKSHAFTS

60 hp to 350 hp

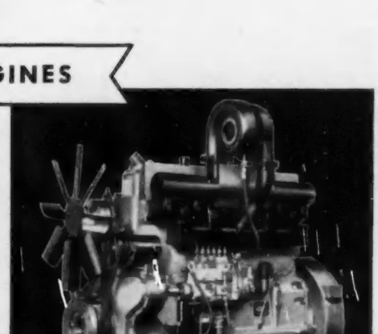
TYPICAL WAUKESHA TRUCK ENGINES



195-GKA—GASOLINE—6-cyl., 4⅛-in. x 4-in., 320 cu. in. displacement, Maximum hp. 122 @ 3000 rpm.



148-DKB—NORMAL DIESEL—6-cyl., 5¼-in. x 6-in., 779 cu. in. displacement, Maximum hp. 200 @ 2100 rpm.

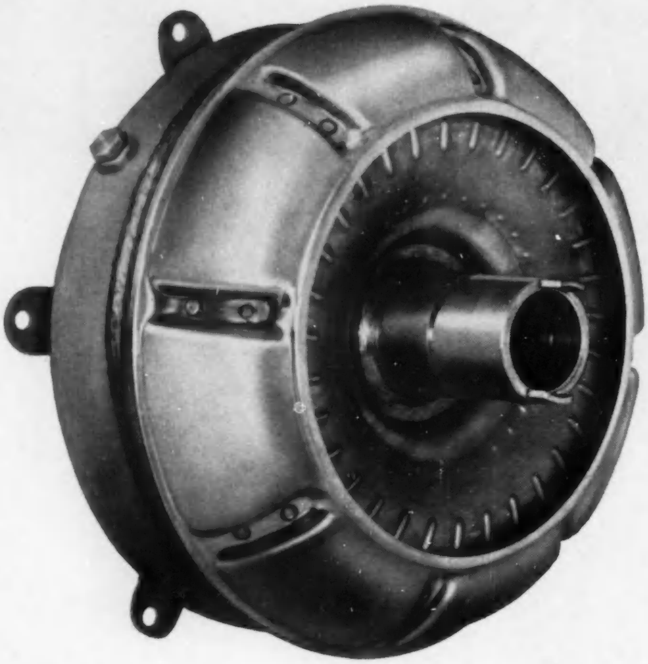


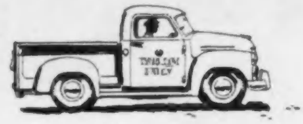
WAKDBS—TURBOCHARGED DIESEL—6-cyl., 6¼-in. x 6½-in., 1197 cu. in. displacement, Maximum hp. 352 @ 1800 rpm.

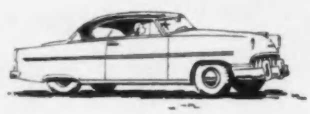
For Details on the Complete Waukesha Line—Get Bulletin 1079

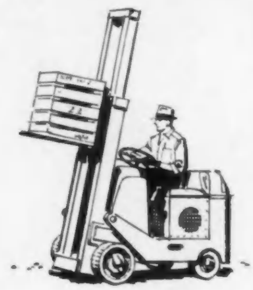
242

WAUKESHA MOTOR COMPANY, WAUKESHA, WISCONSIN • NEW YORK • TULSA • LOS ANGELES









Which is the CleCap?

...the outsize one that nobody else makes

One of the advantages CleCap customers enjoy is the knowledge that when they want some of those BIG cap screws, the chances are 9 out of 10 we can ship them the same day.

CleCap makes 'em from ¼" to 2½" diameters, any length you want—ferrous and non-ferrous—and we stock a lot of unusual sizes, nearly 10,000 different items last count.

That's another reason for dealing with *The* cap screw specialists of the country. You also get unbeatable top-quality fasteners . . . PLUS a CleCap crew that has a long-made rep for "busting a leg" to get you what you want exactly when you want it.

What happens to your profits when late deliveries hold up production lines? Put your cap screw needs up to CleCap . . . and relax!

The Cleveland Cap Screw Co.

2947 EAST 79TH STREET • CLEVELAND 4, OHIO

VUlcan 3-3700 TWX CV42

Warehouses: Chicago • Philadelphia • New York • Providence • Los Angeles

CLEVELAND *Top Quality* **FASTENERS**

Ferrous and Non-Ferrous

Hex Head Cap Screws—Bright and High Carbon Heat Treated Steel, Brass, Silicon Bronze, Stainless Steel; ¼" to 2½" dia.

Socket Head Cap and Set Screws—Plain and Knurled ¼" to 1½" dia. Also Flat and Button Head Styles.

Flat Head Cap Screws: ¼" to 1" dia.

Fillister Head: ¼" to 1¼" dia.

Set Screws—Square Head: ¼" to 1½" dia.

Milled Studs: ¼" to 1¼" dia.

Plow Bolts: ¼" to 1⅛".

Structural Bolts to ASTM Specification A325

Tractor Bolts

Special Hot and Cold Headed Parts

Facilities to make larger diameters than listed.

Ask Your Jobber for CleCap!

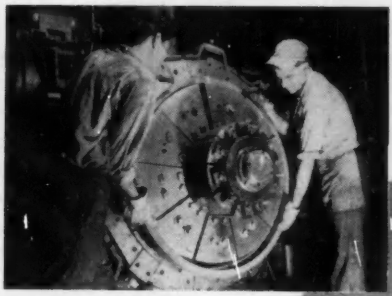
Originators of the Kaufman DOUBLE EXTRUSION Process

More here than meets the eye...

Pictured below are three important steps in the making of a welded jet-engine-compressor ring by the Cleve-Weld Process. Not pictured, but very evident in the metallurgical and physical accuracy of the finished product, are the numerous tests and inspections which accompany every step in its production, beginning with the raw steel bar stock from which it is rolled.

This roll-and-weld process, by which we produce thousands of high-temperature-alloy and stainless steel rings for Pratt & Whitney J-57, Curtiss-Wright J-65, General Electric J-47 and other turbo-jet engines, is explained and illustrated in more detail in a new 28-page brochure. We'll gladly send you a copy to acquaint you with our extensive, specialized facilities for serving *your* ring needs. Write THE CLEVELAND WELDING COMPANY, West 117th Street and Berea Road, Cleveland 7, Ohio. (A subsidiary of American Machine & Foundry Company, New York.)

Rolled from a flat bar into circular shape, stainless steel ring's abutting ends are flash-butt-welded on huge 750 KVA resistance welder.



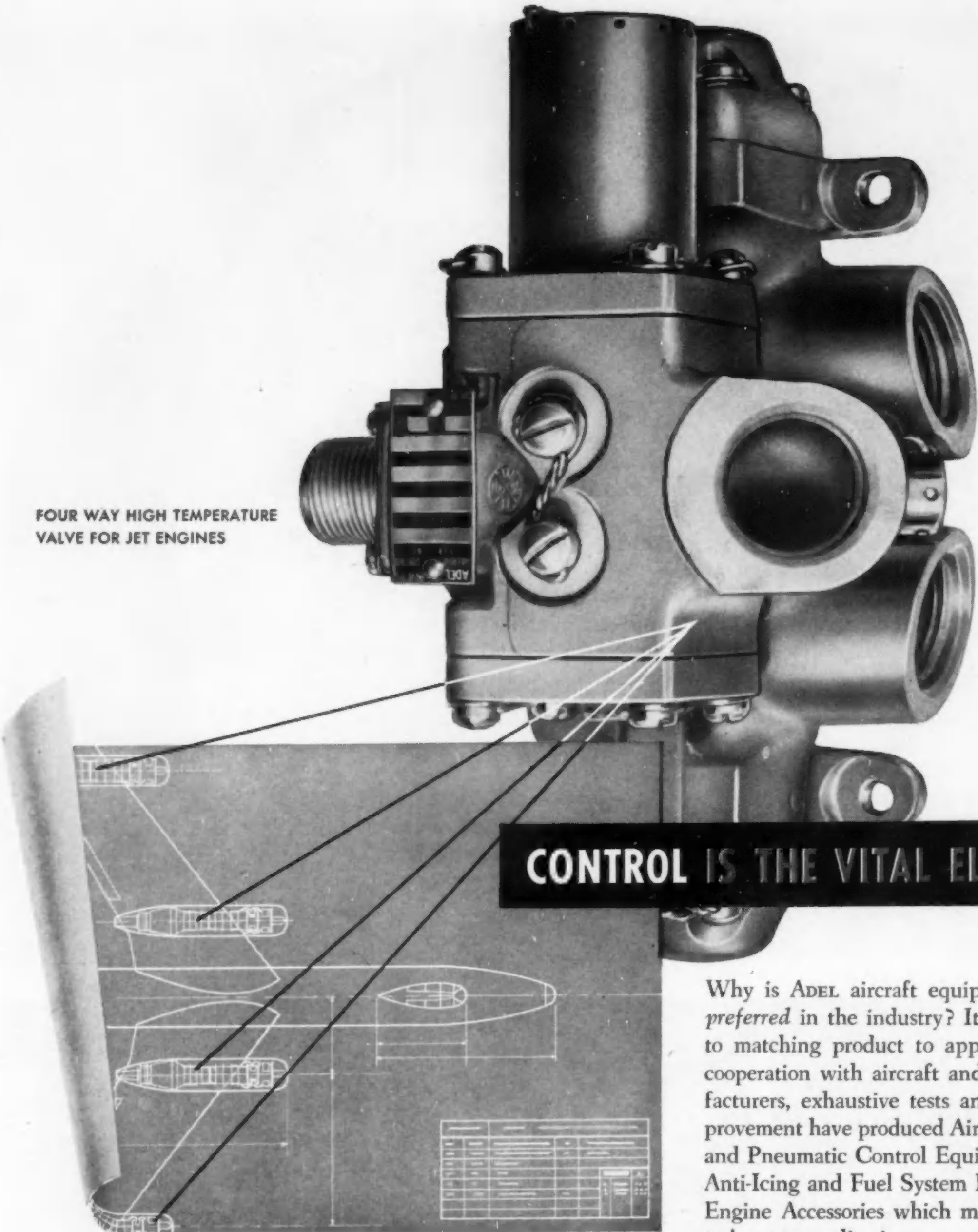
Welded ring, with flash removed, is expanded under tremendous pressure both to test the weld and to form a more perfect circle.

In this 400-ton hydraulic press the ring is flattened to meet dimensional specifications.

Another AMF Product

CLEVE-WELD PROCESS

JET ENGINE RINGS



FOUR WAY HIGH TEMPERATURE
VALVE FOR JET ENGINES

CONTROL IS THE VITAL ELEMENT

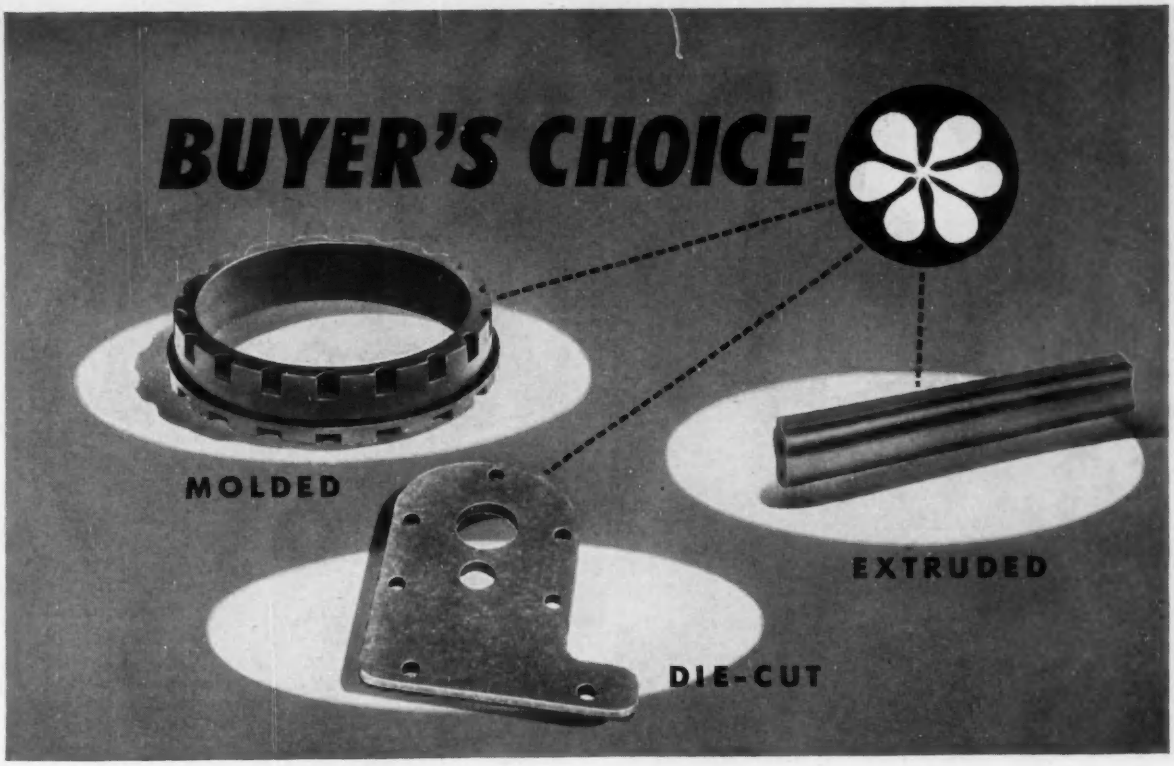
Why is ADEL aircraft equipment the *most preferred* in the industry? It all boils down to matching product to application. Close cooperation with aircraft and engine manufacturers, exhaustive tests and constant improvement have produced Aircraft Hydraulic and Pneumatic Control Equipment, Heater, Anti-Icing and Fuel System Equipment and Engine Accessories which match the industry's every application.

Above all, ADEL has the combination of specialized talent, experience and unequaled facilities essential for the successful solution of aircraft and engine control problems.

ADEL . . . *Foremost in performance . . .*

A DIVISION OF GENERAL METALS CORPORATION
BURBANK, CALIFORNIA • HUNTINGTON, WEST VIRGINIA
CANADA: RAILWAY & POWER ENGINEERING CORPORATION, LIMITED

ADEL



*ACADIA SYNTHETIC RUBBER PARTS ARE MADE ALL 3 WAYS!

With Acadia you have a *choice!* Not only molded rubber . . . not only molded and die-cut . . . not only extruded rubber . . . but rubber parts any way you require! Better yet, Acadia uses whatever method the requirements of the job and you dictate is the *best* way to do it.

Acadia is especially sensitive to your specifications. We will process synthetic components for oil-resistance—good aging properties — resistance to heat — any characteristic you're seeking, or a combination of characteristics. Acadia parts are cut, molded or extruded to all required shapes, sizes and types, with almost unlimited applications.

Also, we offer Acadia SILICONE Rubber, molded or extruded for gaskets, seals, "O" rings, washers, sheets, cut-parts and packings. This is the rubber that will stay resilient at 100° *below* zero, or 500° above!

There's an Acadia Sales Engineer near you to serve you. Write us today, and we'll put him in touch with you immediately.

ACADIA Synthetic PRODUCTS

DIVISION OF WESTERN FELT WORKS

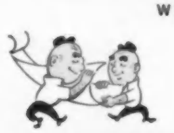
4035-4117 Ogden Ave., Chicago 23, Illinois
Branch Offices in Principal Cities

MANUFACTURERS AND CUTTERS OF WOOL FELT

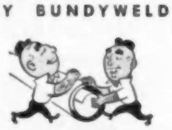
It almost goes without saying that leakproof Bundyweld can be depended on for reliable performance. It is axiomatic, too, that Bundyweld takes easily to intricate fabrication steps. Above, left, vent tube for use inside gasoline filler tube presented a problem: how to remove possibility of gasoline entering two side vents as gas tank was filled. New design suggested by Bundy completely protects vent from gasoline entry by baffle deflection; requires two fabrication operations: one to flatten end and pierce tube simultaneously, one to put double bend in flattened part.

Skip the trial-and-error process--change to Bundyweld now!

WHY BUNDYWELD IS BETTER TUBING

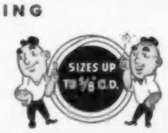


Bundyweld starts as a single strip of copper-coated steel. Then it's . . .



continuously rolled twice around laterally into a tube of uniform thickness, and

passed through a furnace. Copper coating fuses with steel. Result . . .

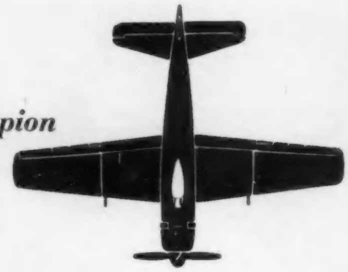


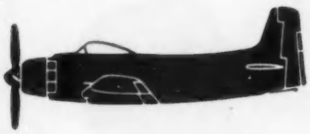
Bundyweld, double-walled and brazed through 360° of wall contact.

← **NOTE** the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead and less chance for any leakage.

Newest version of the

world's single-engine weight-lifting champion





the U.S. Navy's

Douglas AD-6 Skyraider

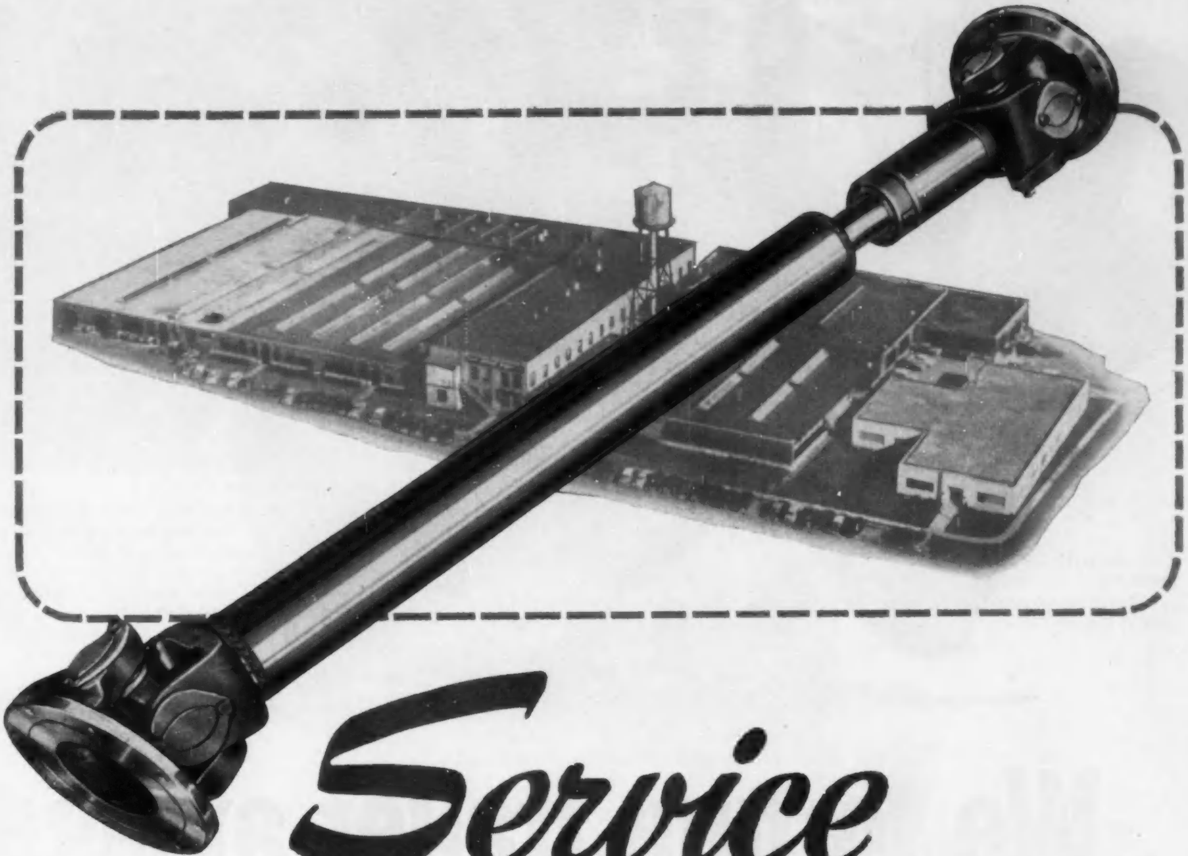
Few aircraft can rival the over-all record of the Douglas AD Skyraiders. Here is a piston-engine series that holds its own with honor in the jet age.

Now comes the newest version of Skyraider—the Douglas AD-6. A hint of its efficiency can be seen in the world record set by its predecessor, the AD-4, which recently took off with a useful load of 14,941 pounds—*three thousand pounds more than its own basic weight.* Most versatile planes in the air, the AD Skyraiders can handle 22 different assignments—a usefulness which will be extended even farther by the new AD-6.

Development of the AD-6 Skyraider is another example of Douglas leadership in aviation. The development of planes that can be produced in quantity—*to fly faster and farther with a bigger payload*—is the basic rule of Douglas design.

Be a naval flier—write to:
Nav Cad, Washington 25, D.C.

Depend on *DOUGLAS* First in Aviation



Service

is an Attitude...

At Blood Brothers, Service is the "attitude of the day"— every day. As manufacturers of propeller shafts for heavy-duty automotive use, Blood Brothers believes that willing, helpful cooperation is the key to improved performance, better products and greater customer satisfaction.

At times, your model changes necessitate altered specifications . . . or technical problems require expert advice . . . or you are called by customers who want replacement parts.

At such times, we're confident you'll find Blood Brothers alert, willing and able to solve universal joint and propeller shaft problems — for *sure!*

DIV.

UNIVERSAL JOINTS AND DRIVE LINE ASSEMBLIES

BLOOD BROTHERS machine division
Rockwell Spring and Axle Company
ALLEGAN, MICHIGAN

We torture trailer axles to

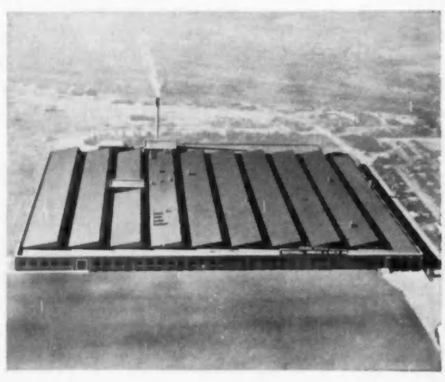
in the new Timken-Detroit indoor proving ground ... and only Timken has it!

We shock-load, abuse, and torture them. Match every conceivable hauling condition. Then add a few brutal tricks of our own!

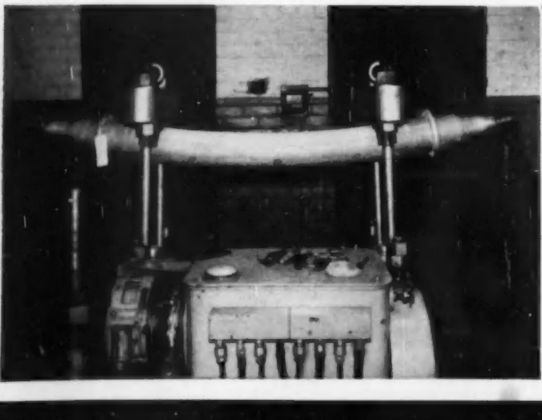
Why? So you'll know in advance, and *for sure,* that a Timken-Detroit axle can take the punishment it was designed for. More rugged, grueling punishment than any other trailer axle made!

To prove it, we capsuled a multi-thousand acre proving ground into one room. Here our engineers can put 50 years of experience in building axles for trucks, buses and trailers to work—subjecting axles and gearing *indoors,* to any *outdoor* operating condition.

Such exacting research pays off for you in: longer axle life; less maintenance, repairs and downtime; reduced operating expenses. That is why Timken-Detroit axles are preferred by manufacturers and operators everywhere.



Manufactured in the world's largest, most modern trailer axle plant, Timken-Detroit axles and brakes are *standard equipment on the majority of trailers on the road today!* This is the TDA Kenton, Ohio, plant, staffed by highly trained technicians . . . backed by over 50 years of TDA engineering experience. You are cordially invited to visit us at any time.

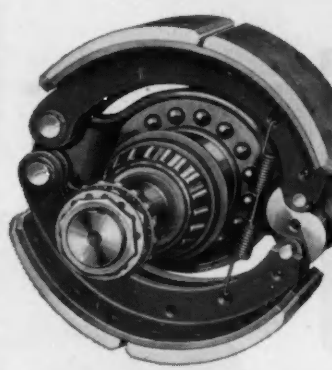


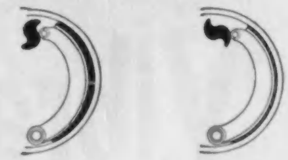
How TDA proves axle quality and safety in this "Torture Chamber"

We pick one of our trailer axles at random . . . then duplicate an overload on bumpy roads hour after hour, day after day . . . or simulate 500,000 miles of the toughest hauling conditions in just a few days. Or we shock-load a trailer axle . . . give it the "bend test" for as many as 1,000,000 cycles or to destruction!

Timken-Detroit tubular trailer axles are lighter to give you greatest possible pay load. Timken-Detroit trailer axle and brake assemblies are proved far stronger, more rugged in "Torture Chamber" tests. Note how TDA pressed steel brake shoes alone save many pounds per axle over cast shoes.

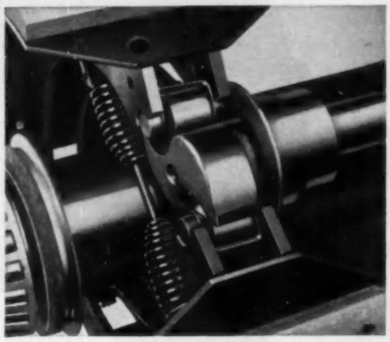
Here are only a few reasons why you should feature Timken-Detroit safety tested quality built axles





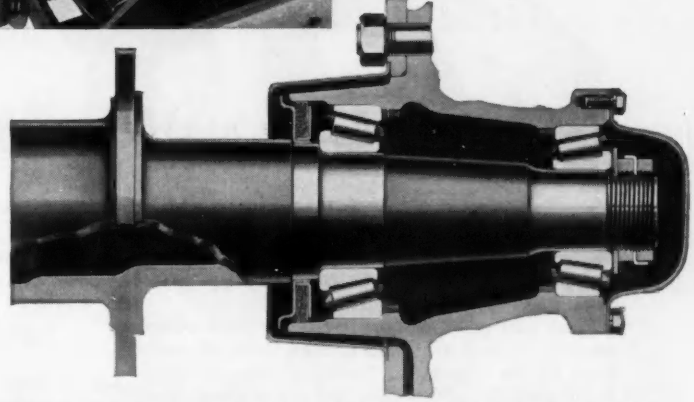
NEW WORN

Exclusive ¾" TDA "Econoliner" brake liners. Thickest at center where greatest wear occurs. Taper down at ends. Held rigidly by 12 deep set rivets per block. Spider riveted to flange. New design decreases operating temperatures, increases safety, cuts down excessive wear.



TDA cam roller mountings will never seize. Roller will not brinell in camshaft. Note clean finish . . . heavy stamped steel straddle support for long life.

death



TDA forged alloy steel spindle, electrically welded to seamless tube. Brake mounting flange forged integral with spindle. Duplicates of this spindle are constantly given the brutal TDA "Torture-Test" to check on quality of materials and workmanship.

TIMKEN *Detroit* AXLES

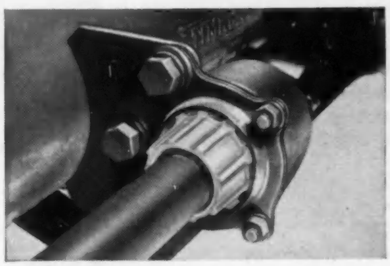
TIMKEN-DETROIT AXLE DIVISION
ROCKWELL SPRING AND AXLE COMPANY
DETROIT 32, MICHIGAN

The Accepted TDA Standard
TRADE MARK REGISTERED

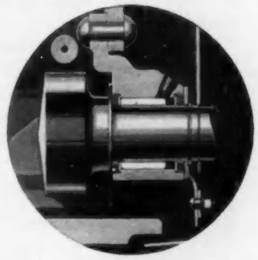
"TORTURE-TESTED" *to Save Money on the Job*

All leading Trailer manufacturers specify Timken-Detroit safety tested quality built axles and brakes

WORLD'S LARGEST MANUFACTURERS OF AXLES FOR TRAILERS, TRUCKS AND BUSES



TDA self-aligning camshaft support bracket. Spherical support permits instant alignment during assembly or replacement. Light nylon camshaft bushings wear up to 4 times as long.



Cutaway view shows cam mounted in new nylon bushing. Minimum wear even when bushings are not lubricated or improperly lubricated. Cannot rust, corrode or flatten out. Save weight.

Plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York • Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

Vibration testing made easier

Electronic component under test at Eclipse-Pioneer division of Bendix Aviation Corporation.

with the help of MB equipment like this

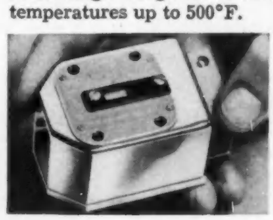
Do you have to vibration-test your product to meet military specifications? Want to apply shake-testing to improve product design or to control quality? If so, do what many leading companies have done—enlist the help of MB.

First, you get the right equipment. MB offers a *complete* line of vibration exciters from 10 pounds force all the way to the largest developed today—10,000 pounds! All are quality built to stand up and do the job right to specifications. Electromagnetic in operation, they're easily and quickly adjusted for force and frequency. And, second, you get the benefit of MB's wide experience in applying this relatively new and valuable technique for product improvement.

Among the well known companies working with MB products, Bendix Aviation Corporation's Eclipse-Pioneer division is outstandingly equipped with *several* MB Vibration Exciters. The photograph shows one—MB Model C-25, rated at 2500 pounds of force—vibrating an electronic component to insure dependability under severest conditions. Such testing can uncover, in minutes, trouble that might take months to develop.

VIBRATION PICKUP ANOTHER USEFUL TESTING TOOL

When you want to detect vibration and determine its nature, you'll want an MB Vibration Pickup. While the pickup detects even slightest vibratory motion, it was built for grueling service as well. Model 122 withstands temperatures up to 500°F.



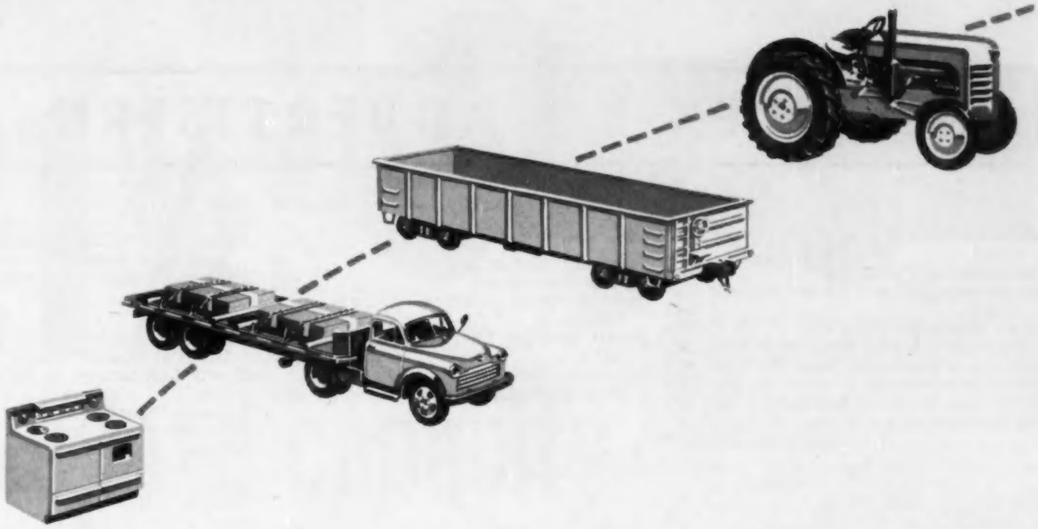
Control panels for all MB shakers, as in the photo above, can be furnished with MB Vibration Meter for use with pickup. This meter gives direct velocity, acceleration and amplitudes of the picked-up vibration.

Bulletins you'll welcome

How to calibrate vibration pickups to 2000 cps—Bulletin C-11-7 reviews the subject comprehensively. Bulletin 1-VE-7 tells all about MB Vibration Exciters. Write for them.

THE MB MANUFACTURING COMPANY, INC.
1060 State Street, New Haven 11, Conn.

HEADQUARTERS FOR PRODUCTS TO INDUCE VIBRATION...TO MEASURE IT...TO ISOLATE IT



Make it **WEIGH LESS** and **LAST LONGER** with

N·A·X

HIGH-TENSILE STEEL

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel—it can be cold formed as readily into the most difficult shaped stamping.

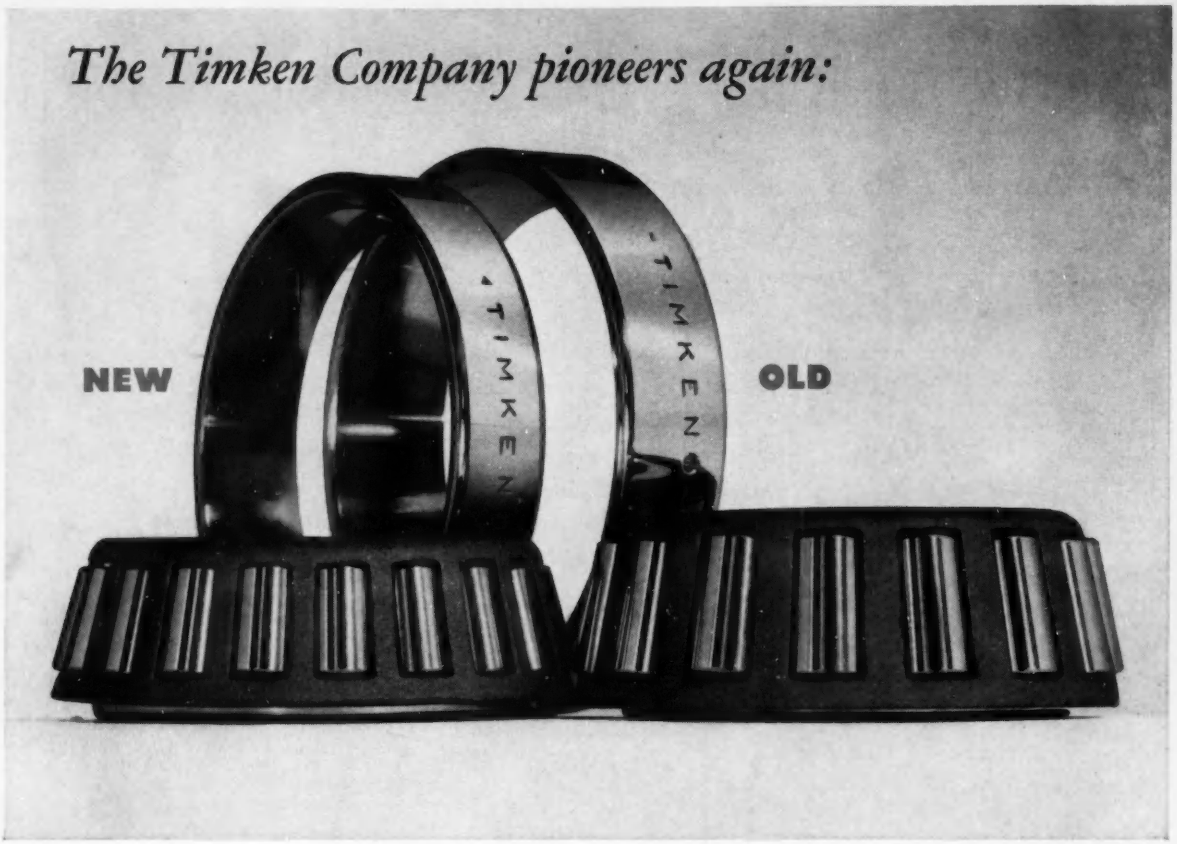
Sound like something for you? Ask for full facts and think of N-A-X HIGH-TENSILE when you re-design.

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division • Ecorse, Detroit 29, Michigan

NATIONAL STEEL CORPORATION

+ INDEX TO ADVERTISERS +



New TIMKEN® bearings for front wheels save money, space, weight

THE Timken Company announces two new front wheel tapered roller bearings, substantially smaller in size, yet with ample load-carrying capacity for over 85% of today's cars. They save space, weight and money.

The new Timken® bearings cost less than the bearings previously used. They are substantially smaller in width and outside diameter. They are more than 25% lighter.

This is the latest achievement of Timken Company research and engineering, which have pioneered many important advances in steel, surface finish and design of tapered roller bearings.

CUTS COSTS

The new design of these Timken bearings can save you money in more ways than one. With proper engineering, the bearing spread may be reduced. This means both hub and spindle can be shorter and less costly to machine.

Being smaller, the new Timken bearings take less lubricant. Both hub cap and seal will be smaller—and less expensive.

Taken individually, these savings are small. Added to the saving per car set in bearing cost, they become substantial.

CUTS UNSPRUNG WEIGHT

Reduction in bearing size brings reduction in space needed and weight. The hub, hub cap, inner seal, lubricant and spindle can all weigh less. Taken along with a .46-pound weight saving per car set in the bearings themselves, it's a worthwhile contribution to smooth riding.

If you haven't seen the new Timken bearings yet, call your Timken Company representative, or write: The Timken Roller Bearing Company, Canton 6, Ohio. Cable address: "TIMROSCO".

TIMKEN is number 1 for VALUE where value counts most... in the vital zone

TRADE-MARK REG. U.S. PAT. OFF.

NOT JUST A BALL NOT JUST A ROLLER THE TIMKEN TAPERED ROLLER BEARING TAKES RADIAL AND THRUST LOADS OR ANY COMBINATION